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AUTHOR	Bauch, Klaus Dieter
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ABSTRACT

The study was designed to investigate the effects of Numerical Control Technology and Computer-Aided Manufacturing (NC/CAM) in American industry on industrial education and engineering technology education. The specific purpose was to identify a data base and rationale for curriculum development in NC/CAM through a comparison of views by industrial NC users and educators regarding appropriate instructional content for educational programs in this technology. Methodology involved a national survey requiring the completion of a two-part questionnaire by over 400 industries and approximately 100 educational institutions. Based on survey findings, recommendations are offered for curriculum development to meet industry needs. Five major areas of NC/CAM are suggested in three levels from introductory, intermediate, to advanced programs with the specific number of courses required to be determined by the particular institution. These areas are basic and general NC concepts, manual programming for NC, computer-assisted programming for NC, management and economic aspects of NC, and advanced technologies. Appendixes to the report include correspondence, the survey instruments, and tables analyzing the data obtained. (RG)

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THE IMPACT OF NUMERICAL CONTROL TECHNOLOGY AND COMPUTER AIDED MANUFACTURING ON CURRICULUM DEVELOPMENT IN INDUSTRIAL EDUCATION AND TECHNOLOGY

A FINAL REPORT (TEA CONTRACT #62360127)

Prepared by

KLAUS DIETER BAUCH
Principal Investigator

DR. JAMES L. BOONE, JR.
Project Director

Submitted to
The Department of Occupational Education and Technology
Texas Education Agency

by
The College of Education
Department of Industrial Education
Texas A&M University

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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ABSTRACT

THE IMPACT OF NUMERICAL CONTROL TECHNOLOGY
AND COMPUTER AIDED MANUFACTURING ON
CURRICULUM DEVELOPMENT IN INDUSTRIAL
EDUCATION AND TECHNOLOGY. (August 1976)

Klaus Dieter Bauch, B.S., Mechanical Engineering School, Germany
M.Ed., Bowling Green State University

Directed by: Dr. James L. Boone, Jr., Head of Industrial Education
Dr. Robert P. Beals, P.E., Industrial Engineering

Purpose

The purpose of this research was to investigate the effects of numerical control technology and computer aided manufacturing in American industry on industrial education and engineering technology education. The specific purpose was to identify a data base and rationale for curriculum development in NC/CAM through a comparison of views by industrial N/C-users and educators regarding appropriate instructional content for educational programs in this technology.

Procedure

The required information was obtained through a nationwide survey of industrial organizations and post-secondary educational institutions

selected on the basis of their involvement in and utilization of N/C technology.

A preliminary survey identified present and planned N/C instructional programs and, together with material from industrial training services, provided exemplary curriculum materials for the design of the main survey instrument. The initial questionnaire was validated by a jury of educational and industrial professionals and pilot tested in Texas. The data received from the nationwide survey was compiled and analyzed through various computerized statistical programs.

Conclusions

The following conclusions, based on the data analysis of the industrial and educational surveys, were drawn:

1. Present instruction in numerical control technology in industrial education and engineering technology programs, although differing considerably among institutions, does not always reflect the current status of this technology in American industry.

2. Based on the present and projected need for new N/C personnel, it appears that educational institutions do not yet provide sufficient instructional programs in this new technology, particularly in the area of computer aided manufacturing.

3. Differences are apparent between present N/C programming practices, techniques, and languages employed in industry and those currently taught in education.

4. In comparing industry's and education's selection of appropriate curriculum content for educational programs in NC/CAM both groups generally agreed on the value of Basic N/C Concepts and Manual Programming.

5. Different value ratings were given to topics relating to the areas of Computer Programming, Management Aspects and Advanced Technologies. Industrial respondents generally considered these areas to be of moderate to substantial importance as compared to educator's less than moderate importance ratings.

Recommendations

Based on the survey results some general guidelines for detailed curriculum development in numerical control and computer aided manufacturing are recommended:

1. Five major areas of NC/CAM are suggested in three levels from introductory, intermediate to advanced programs with the specific number of courses required determined by the particular needs and purposes of the institution and its students. These five main areas, with the approximate total percentages for all three levels, are the following:

(1)	Basic and General N/C Concepts	(15 percent)
(2)	Manual Programming for N/C	(25 percent)
(3)	Computer Assisted Programming for N/C	(25 percent)
(4)	Management and Economic Aspects of N/C	(20 percent)
(5)	CAD/CAM Advanced Technologies	(15 percent)

2. At the Introductory Level I, emphasis should be placed on a combination of General N/C Concepts (30 percent), Manual Programming (40 percent), Introduction to Computer Programming (10 percent), and Management Aspects (20 percent).

3. At the Intermediate Level II, the proportion and emphasis should shift from Manual Programming (30 percent) to Computer Assisted Programming (30 percent). General N/C Concepts (10 percent) should be reduced in favor of an introduction to Advanced Technologies of Computer Aided Design and Manufacturing (10 percent), and continued Management Aspects (20 percent).

4. At the Advanced Level III, Basic and General Concepts should be phased out and replaced by Advanced Technologies (30 percent), Manual Programming (10 percent) should be reduced to allow for expansion of Computer Programming applications (40 percent) while the portion of Management Aspects of N/C (20 percent) should remain constant.

PREFACE

The completion of a research project, involving a nationwide survey, depends on many factors essential for the success of such a venture, but above all it depends on the unselfish assistance and support of many individuals. Therefore, appreciation is extended to the more than six-hundred professional experts from industrial enterprises and teaching faculty from colleges and universities across the nation who made this research possible by participating in the surveys. Without their valuable cooperation and essential input, a study of this scope and nature could not have been accomplished. Thanks also goes to those who provided professional counsel and expert advice by serving on the project advisory committee.

Special gratitude is expressed to Dr. Robert P. Beals, P.E., Associate Professor of Industrial Engineering, who served as technical consultant on the advisory committee and Dr. Jon F. Botsford, Assistant Professor of Engineering Technology for his support and encouragement. Sincere appreciation is also extended to Gerald Chen, research assistant, for his untiring assistance and dedication to the project.

Appreciation is also expressed for the cooperation of the Department of Occupational Education and Technology at the Texas Education Agency for their interest in and support of research studies relevant to curriculum development in industrial education and technology.

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CHAPTER I

INTRODUCTION TO THE STUDY

Education has always been faced with the challenge of planning curricula that are relevant to the individual's present needs and, at the same time, be of value to the individual during the development of his or her professional career. Since the knowledge base for industrial education is technology, it is imperative that we continuously review the current scientific and technological developments of industry and update our educational programs accordingly.

The diminishing energy sources and environmental needs are forcing industry to search for better methods and more economical processes to achieve maximum productivity. These developments are leading to the increased integration of numerically controlled manufacturing equipment and computer aided manufacturing processes into American industry.

In view of the accelerating rate of change in our technological society, the task of developing curricula that reflect both current technology and anticipated trends becomes increasingly demanding. Based on the premise that industrial education derives its curriculum content from industrial technology, this study investigated the impact of numerical control technology and computer aided manufacturing on curriculum development in industrial education and technology.

Background and Significance of the Problem

In reviewing the recent studies and national surveys on new careers and future employment predictions, some distinct trends and characteristics of new job opportunities can be identified. A steadily increasing demand for highly skilled and well educated personnel, particularly in manufacturing industries, is expected according to the Bureau of Labor Statistics (November, 1971). Similar trends were forecast in the following reports: Education and Training, Ten Years of Progress, (1972), Manpower Research in the 1970's, (1971), National Assessment of the New Careers Program (1970), Monthly Labor Review (March, 1975).

Department of Labor Statistics (November, 1971) project an eleven percent increase in job openings in the manufacturing industries from 1968 to 1980. Professional, technical jobs are expected to increase by over 50 percent, making it the fastest growing area. Within this category more than 100 percent increase is anticipated for systems analysts and programmers (this includes numerical control and computer programmers). If one of the purposes of industrial education is to reflect modern industry and technology, then the significance of these trends and new developments become obvious.

The presidential report on manpower requirements, resources, utilization, and training (March, 1973) summarized the corresponding decline in the number of jobs for the unskilled:

> The steady decline in the relative numbers of less-skilled and less-educated workers is paralleled by a decline, partly attributable to technological advances, in the relative number of jobs requiring only limited skills and education.

With respect to the impact of modern technology on educational requirements, the United States Department of Defense Industry Symposium (1969, p. 275) stated:

1) New technical skills are required for programming the new machines in their new technologies and sharper managerial skills are required to carry out those functions not committed to the computer.

2) Successful implementation of CAM will require large scale training efforts throughout industry, government, academia, and technical societies to include middle and top management levels, user levels, and operating and maintenance levels.

3) The technology is developing so rapidly that educators at all levels, from junior high through the doctorate levels, find it difficult to establish courses which have any long term validity.

The dynamic aspects of this technology may require an imaginative approach to the entire relationship of education/training and employment. A lack of knowledge of the challenges presented by the computerized world makes communication between education and industry more difficult than it is in other more familiar areas of our contemporary technology. Furthermore, since job opportunities are so varied and in a continuous state of development, a clear definition of their long-term potential is difficult to assess.

Campbell and Harrison (1975, p. 147), investigating the demand for a skilled workforce for N/C technology, contend that:

> . . . machines have traditionally been thought of as being an extention of 'man's hand' - with N/C the concept goes further. The role of N/C is the extention of man's mind through a machine.

Similarly, Edward E. Miller, Senior Staff Engineer of Western Electric Co., Inc. refers to the impact of new technology on education in the following manner:

> Such a concept can become reality only to the extent that education can be effective at all levels of society and a new level of interdisciplinary communications can be developed. The impact of education of both new technology and increased social awareness needs to be recognized and quantified wherever possible. (1975, p. 46).

There are educators who feel that public education can and should meet the challenge of orienting students to N/C technology. Realizing the undeniable importance of relating the content of industrial education to the realities of modern industry, Rupert Evans said as early as 1962, that "we can . . . set up educational programs which reflect adequately the role of technology and industry in our society" (Evans, p. 110). More recently, Clark believes that the ". . . widespread increase of N/C in industry has created a demand for workers with the skills and competencies required by it" (Clark, 1975, p. 42).

Miller also points out that ". . . the curve of technological progress is reaching the perpendicular. Next year, or even tomorrow,

may be too late to make the student fully aware of the effect of technological change in manufacturing."

Despite the commitment expressed by educators in the field, educational realities seem to fall short of fulfilling the promise, due to the seemingly prohibitive cost of equipment or lack of information on the part of educational institutions. Although N/C machine tools were first introduced in the 1950's, public education did not participate in the new technology until 1965 when the APT education agreement was developed and signed by 38 public educational institutions (Illinois Institute of Technology Research Institute, Chicago, 1967).

In fact, in a 1966 questionnaire prepared by McWaters (1966, p. 5, Appendix B), only one of the 61 responding colleges in 28 states expressed the need for N/C machine tools. If the data showed indifference in 1966, it is of importance to know if there has been a change of attitude since then in higher education. It is important to know what types of curricula already exist in the school system, and to determine their effectiveness in orienting students to the realities of modern industry. Without knowing where industry and public education stand on the issue at present, it is impossible to determine what role educational institutions will play in the future, when industry is sure to rely more on N/C technology.

Statement of the Problem

Current instructional programs in N/C technology vary considerably in content and methodology with the amount of time dedicated to specific curriculum elements differing widely from one institution to another. Since little empirical data and detailed information on appropriate subject matter exists, a persistent problem encountered is the lack of valid industry-oriented curricula.

Considering the increased sophistication of manufacturing processes, particularly in the areas of N/C technology and computer applications, it becomes imperative to develop a rationale and knowledge base for the design and implementation of curricula that are reality-oriented. In order to update present programs and to lay the foundation for future curriculum change, it is essential that we investigate the sources for the selection of instructional materials for industrial, vocational, and technical education. Based on the identified need for relevant curricula in N/C technology, the specific objectives of this research were:

1. To determine the opinion of knowledgeable representatives from industry regarding the tasks required of personnel working in the field of numerical control and computer aided manufacturing,

2. To determine the opinion of educators who teach numerical control in regard to curriculum content required in this area,

3. To compare and review the opinions of industrial representatives and educators in regard to requisite tasks and training

topics which will serve as a basis for future development of appropriate instructional material,

4. To select requisite tasks and training topics from the survey results and integrate these into a suggested curriculum outline.

The findings of this study will enable educational institutions to develop courses geared to their particular needs and resources, but also responsive to actual industrial requirements. Depending on the specific goals and educational levels of the programs, such as secondary, vocational, post-secondary industrial-technical, or industrial teacher education, instructional content may be derived from the selection of required tasks as outlined in the curriculum model.

Basic Assumptions

For the purpose of this study, several fundamental assumptions were made relative to the nature of the problem:

1. It is the responsibility of industrial education and engineering technology to provide students with educational programs that realistically reflect technological developments by deriving the course content from contemporary industry.

2. Educational programs in numerical control/computer aided manufacturing must be constantly monitered and updated as industrial applications of technology change.

3. The sample of N/C-users selected from industry is sufficiently representative of the total population by including all members of Computer-Aided Manufacturing-International (CAM-I, Inc.) and individual members of the Numerical Control Society (NCS).

4. The educational sample is sufficiently representative of the total population since it consists of all individuals answering to a preliminary survey which identified present and planned N/C programs in post-secondary institutions.

5. Specific tasks and topics for the development of a curriculum guide can be identified through a comparative analysis of industrial and educational responses to a self-reporting survey instrument.

6. The results of the study are valid only to the extent to which participants of the survey recorded all requested information according to the stated directions with accuracy.

Limitations

The following limitations are applied in order to define the nature and scope of the study:

1. With respect to the educational population, the study was limited to the following participants: (1) all faculty teaching N/C courses at any of the 246 industrial teacher education institutions in the United States as listed in the 1975-76 ACIATE "Industrial Teacher Education Directory;" (2) all faculty teaching N/C

courses at any of 56 ECPD-accredited engineering technology schools in the United States offering four year bachelor's degree programs; (3) all faculty teaching N/C courses at any of 63 post-secondary institutions (junior colleges, community colleges, technical institutes) in Texas offering occupational-technical programs leading to a two-year associate degree as listed in the 1974-75 Texas Education Agency "Information Guide and Directory;" (4) a small sample of selected post-secondary institutions in other states with known N/C programs were added for comparison with similar institutions in Texas.

2. With respect to the industrial population, the study was limited to the following participants: (1) all company and individual members of the Numerical Control Society with the exception of educational, student, and foreign members as listed in the 1976 "Directory of Members Numerical Control Society;" (2) all company members of Computer Aided Manufacturing-International in the United States excluding educational and foreign members as listed in the 1974 "Basic Program of CAM-I, Inc."

Definition of Terms

ACIATE. An acronym for American Council on Industrial Arts Teacher Education. A division of the American Industrial Arts Association and the National Education Association.

APT. An acronym for Automatic Programmed Tools. APT is a computer-based numerical control programming system which uses

English-like symbolic descriptions of part and tool geometry and tool motion.

CAM. An acronym for Computer Aided Manufacturing, it is the technique of using the computer to control manufacturing processes, including process planning, scheduling,and execution.

CAM-I. An acronym for Computer Aided Manufacturing-International, Inc.-an organization for the advancement of the art of computer aided manufacturing systems and the promotion of scientific research in such fields. (Computer Aided Manufacturing-I, 1974, p. 3). (CAM-I replaced the APT Long Range Program in 1970).

Computer. A cybernetic device that will accept information, apply prescribed processes to the information, and produce the results of these processes.

Concepts. Concepts are ways or organizing experiences, giving experiences meaning in terms of some abstract quality of the object or event experienced. (Eson, 1964).

Curriculum Development. The process of determining specific objectives, selecting and organizing content, and learning experiences, and identifying means for their evaluation. (Taba, 1962),

Curriculum Model. A symbolic representation of the total instructional experiences and programs designed to cover the concepts and principles in a designated field of human endeavor. (Gordon, 1968).

ECPD. An acronym for Engineer's Council for Professional Development, a professional agency for the supervision and accreditation of engineering and engineering technology programs.

Educational Training Program. A program with the assumed purpose of developing job relevant human performance capabilities based on defined training objectives and performance requirements. (Ammerman, 1970, p. 112).

Engineering Technology. That part of the engineering field that requires the application of established engineering and manufacturing principles to the design and production of goods and services.

Industrial Education. A generic term which includes vocational-industrial education, industrial arts, technical education, and apprenticeship training.

Industrial Technology. That part of the engineering field that requires the application of scientific and engineering principles to solve production problems or to coordinate personnel oriented needs at the supervisory or production management level.

Manufacturing Industry. An agency that produces durable and nondurable goods according to an organized plan and utilizing a division of labor concept.

Mechanical Technology. That part of engineering technology concerned with established procedures in production, testing, and service of mechanical parts and apparatus as well as supporting aspects of research and development.

NC/CAM. An acronym for Numerical Control/Computer Aided Manufacturing. Consists of the coupling of the computer to the production facilities of a plant to produce equipment, devices, and parts.

NCS. An acronym for Numerical Control Society. A professional organization which provides opportunities to contribute to and learn about the application and technology of numerical control in all industries. (Numerical Control Society, 1975, p. 3).

N/C Technology. An acronym for Numerical Control Technology. It is the technique of controlling a machine process utilizing instructions in symbolic form.

Occupational-Technical Programs. Concerned with various program areas, usually at the post-secondary level, to prepare individuals for specific occupations in technical fields. (Texas Education Agency, 1974-75).

Task. An action or action sequence grouped through time designed to contribute a specified end result to the accomplishment of an objective and for which functional levels of orientation can be reliably assigned. (Fine & Wiley, 1971, p. 9).

Technical Education. That body of knowledge, usually at the post-secondary level, that prepares pupils for a cluster of job opportunities in a specialized field of technology. (Texas Education Agency, 1974, p. 5).

Technology. The applied arts that use scientific knowledge for control of matter, energy, and information to accomplish useful purposes.

Training Topic. One part or element of a training program or educational curriculum derived from a realistic analysis of the tasks, duties, responsibilities and occupational objectives of specific

occupations or clusters of similar occupations.

Vocational-Technical Education. Education for technical occupations based upon technical information and an understanding of technology as applied to modern design, production, distribution, and service.

Procedure

Although the research methodology is described in detail in Chapters III and IV, a brief outline of the procedure followed is provided here for reference:

I. Selection of the survey population.
   A. Obtain membership directories of educational institutions, and professional organizations.
   B. Contact all schools and institutions for the purpose of identifying present N/C technology programs and programs planned for the near future.
   C. Compile comprehensive mailing list of all survey participants from educational institutions and N/C-users in industry nationwide.

II. Design and Development of Survey Instrument
   A. Conduct preliminary survey among selected educational institutions, industrial N/C-training and consulting firms, and professional organizations to obtain exemplary program material.

B. Review all relevant program material and conduct comprehensive literature search.

C. Develop tentative survey instrument

D. Determine and invite jury from industry and education to validate survey instrument.

E. Pilot test revised and validated survey instrument in Texas.

III. Collection of Data.

A. Conduct nationwide survey among industrial and educational sample.

B. Follow-up of all industrial and educational survey participants.

IV. Data Analysis

A. Descriptive statistical analysis of survey data and compilation of results.

B. Identification of concepts and tasks required in N/C-technology.

C. Selection of tasks and training topics from the survey results and their integration into a suggested curriculum outline.

D. Formulation of conclusions and recommendations based on analysis and interpretation of survey data.

CHAPTER II

REVIEW OF THE LITERATURE

Present and Projected Developments in Numerical Control and Computer Aided Manufacturing

Since the development of the first numerically controlled machine tool at Massachusetts Institute of Technology in 1956, traditional manual machine operations in small and medium size production facilities have changed dramatically. Few technological advances have had a more profound impact upon contemporary manufacturing industries than the concept of numerical control combined with computer aided design and manufacturing.

The NC/CAM guidebook (Modern Machine Shop, 1975, p. 179) described the impact of N/C as follows:

> Numerical control of a machine tool is indeed revolutionary in concept. For with N/C, the control of a machine has moved away from operator skill and intuition to an entirely conceptual documentation of all machine motions and functions needed to machine a workpiece. It is thus very important to realize that N/C is not (just) a machining method. It is a concept of machine control.

With the addition of the electronic digital computer, either during the programming stage or through direct numerical control (DNC), this concept of numerically controlling machine tools is rapidly expanding into an all-encompassing computer aided manufacturing approach beyond the mere control of machining operations. Due to the great influence that the electronics industry has had on the N/C state-of-the-art, numerical control can be regarded as one of today's

most dynamic manufacturing processes, (Conaway, 1969, p. 12).

Campbell and Harrison agree that

> . . . there are few phases of industrial production where more ideas are developing and more new equipment is being utilized than in the field of numerical control. It is perhaps the most rapidly expanding aspect of industrial production, with applications ranging from the smallest machine shop to the largest assembly of manufacturing facilities (1975, p. 148).

According to general estimates, between 70 and 80 percent of all metal working production runs are so-called short runs or lot sizes for relatively small production volumes. For this reason, the decisive economic impact of N/C has been felt in the small job-shops (Conaway, 1967, p. 12). On the other hand, production in medium and large companies has been advanced through the use of numerical control and computer aided manufacturing methods. During the last few years, NC/CAM has made much progress due, in part, to increased applications of the computer, not only for part programming but also for the management and production control of software development.

According to M. Kosem of Allen Bradley Company (1975, p. 79), the many innovations in the N/C industry are strongly related to developments in the computer industry:

> With the advent of the minicomputer we have reached the point where the computer is taking the place of hardware which would otherwise be designed for special applications. And with today's microprocessors, even more powerful and lower cost N/C is here or within easy reach.

Computer Numerical Control (CNC), Direct Numerical Control (DNC), and Adaptive Control (AC) are only some of the newly developed techniques within the expanding computer aided manufacturing environment.

Kosem believes that future trends in N/C design point to computerized N/C which ". . . will become a standard product of ever increasing application potential in terms of lower cost as well as expanding feature requirements" (1975, p.81). Researchers sponsored by CAM-I (Computer Aided Manufacturing-International, Incorporated) are investigating automated process planning systems as one of the priority areas of Computer Aided Manufacturing. Furthermore, C. H. Link, executive director of CAM-I, predicts more extensive use of minicomputers for machine and plant monitoring and management control functions. He indicated that minicomputers ". . . will be dedicated to departmental functions in design engineering, manufacturing engineering, quality control, tooling and inventory control, purchasing and scheduling." (1976, p. 116).

Dr. Joseph Harrington, Jr. (1975, p. 165) contents that computer integrated manufacturing (CIM) is already an important part of today's manufacturing and will eventually be the standard manufacturing technology. He stated:

> Computer aided manufacturing technology is a capital asset, and its acquisition should be given incentives similar to those which encourage the purchase of new machinery. There is need of a forum of communication where engineers and managers can seek mutual assistance, avoid duplication, and expand the field of application for computer integrated manufacturing.

Considering these past advances and predicted trends in manufacturing technology, it becomes increasingly imperative that educators in industrial and technical education shift the emphasis

from traditional manual machine operations to present day industrial skills required by these new technologies.

Miller (1975, p. 47), Senior Staff Engineer of Western Electric Company, Incorporated suggested that:

> . . . the educational community move closer to industry and government in furthering an appreciation of the opportunity inherent in the appropriate implementation of N/C and CAM concepts. In the light of worldwide competition in manufacturing products, we are already late in developing adequate methods for technology interchange for the benefit of our society.

The following section considers the changes in the employment trends of industry due to the increased application of NC/CAM in modern industry.

Employment Trends in the Manufacturing Industries

With the increasing complexity of technological advancements in modern industry, particularly in the manufacturing industries, certain distinct patterns of industrial development and related employment requirements are becoming apparent. With regard to these developments, a panel on the sociological, legal, and educational implications of NC/CAM (United States Department of Defense, 1969, p. 234) asserts the following:

> We have reached a point of progress in our 'advanced' society where scientific-technological know-how has outrun our ability to apply the knowledge in a sensible fashion to the solutions of the meaningful, significant problems facing society currently and in the future. One way of overcoming this seemingly insurmountable obstacle is through education of everyone.

The conclusion that can be drawn from this observation and recent trends in industry is that the highly trained and educated individual is fast becoming the central resource in our society. As a result of technological innovations such as numerical control, entry level requirements for trainees and the demand for skilled technicians will increase,while the demand for less skilled individuals will decrease.

In view of trends such as the continuously changing skill requirements in manufacturing, the challenge to education is to develop curricula with meaningful applications to reality. The need for technology-oriented programs was expressed by Csont when he stated:

> Numerical control is revolutionizing the manpower training requirements of a vast segment of our industrial economy, and we. . . must meet the challenge and prepare our students for good jobs this new technology will be providing (1966, p. 26).

Increased industrial automation will require the modification of traditional industrial edncation curricula to include these new manufacturing processes. Although a number of conventional low-skill jobs may disappear due to the development of more sophisticated machinery, the new occupations that accompany many technological advances could absorb the displaced (United States Department of Labor, 1974b). These changes will require a concentrated effort on the part of educators to update and adapt traditional industrial education programs to educate pre-service, inservice, and displaced workers.

Current projections by the United States Department of Labor (1974b, p. 15) indicate that many of the jobs which will be available in the next decade are occupations presently unknown. Although the general trend of increased employment in the service-oriented industries and administrative occupations will continue, one particular area of increased employment opportunities in the manufacturing industries will be personnel for the manufacturing, maintenance, and service of automated equipment such as numerical control machine tools. The necessary transfer of jobs from certain low-skilled areas to different and often higher-skilled jobs should be regarded as a challenge to all educators concerned with the future employability of their students.

Since numerical control with computer programming and computer control of the machine control unit is directly related to the development of computer technology, it can be assumed that the growth trends of N/C will be strongly related to projected trends of the computer industry. It is under this assumption that the following data is presented.

Continued expansion is forecast in computer use and further advances in computer technology. Over the next several years, these advances will have a large impact on personnel required to use the capabilities of computer systems, particularly in the areas of computer aided manufacturing (United States Department of Labor, 1974a).

The development of more sophisticated computer hardware and software attracts new computer users and increases the number and type of applications among existing users; thus, the demand for certain programmers will increase. On the other hand, the increased sophistication of computers makes possible the development of standardized software packages which enable programming capabilities to be built into the computer equipment itself. This capability will decrease the demand for other programmers. Improvements in the programming field also make it possible for programmers to handle a greater volume of work (United States Department of Labor, 1974c).

Although employment growth will be significant, the jobs for programmers are not expected to multiply as rapidly as they have in the past. However, the rate of increase is faster than the approximate 20 percent rate projected for over-all employment during the same period (1970-1980).

On the other hand, the need for machine tool operators in the manufacturing industries is expected to increase only moderately through the mid-1980's. This projected growth trend is a result of expected expansion of metal working activities.

Both the number and skill requirements of machine tool operators will continue to be affected by technological developments. The development of faster, more versatile, automatic, and numerically controlled machine tools will result in more output per worker and tend to limit employment growth. New processes in metal removal, such as electrical discharge, ultrasonic machining, and the use of

powdered metals that reduce the machining necessary for a final product, will also slow the growth of this occupation (United States Department of Labor, 1975).

The increased productivity due to numerically controlled machine tools will affect the growth patterns of certain job categories in manufacturing. An example was stated in the American Machinist by Ashburn (ed.), (1976, p. 25):

> The U.S. Employment Service's computerized job bank system showed openings in 39 of the nearly 200 job-bank cities early in 1976. The shortage appeared to be most severe in the most skilled areas, especially machine-setup men and master machinists.

This demand exists despite continuing unemployment in other areas of manufacturing.

Thus, experts still believe that the expected expansion of metal working activities, due to increased consumer and industrial demand for machined goods, will keep the overall employment trend on the increase in certain occupations, particularly the highly skilled jobs in numerical control and computer aided manufacturing.

In summary, it can be concluded that the significant trend in employment opportunities, with implications for education, is not the overall growth rate, but the general shift from low-skilled to high-skilled occupations (United States Department of Labor, 1975). Entirely new occupations are developing from expanded computer applications and increased automation, requiring a reorientation of traditional industrial education programs to meet the challenge of our technological age.

Implications of Technological Advances for Industrial Education

Although the existing literature indicates that both, industry and education, are aware of the need to change the educational programs (due to the impact that numerical control technology and computerized manufacturing are having on large sectors of industry), little information is available regarding instructional programs presently offered in N/C. Since published materials concentrate on the basic need for improved communication among institutions of education, industry, and government, this portion of the chapter summarizes the concerns of experts analyzing this aspect of the problem. The Department of Defense Industry Symposium of 1969 (p. 182) noted that:

> Educational institutions do not create the demand for new skills but strive only to fill the demand once the requirements are defined. Only when industry, government, and services make their wants known, only then can education supply the product to meet the requirements.

The Symposium also made the following recommendations with respect to better communications among industry, government, and academia:

> Both industry and government should belabor the academies for applicable curricula in computer aided manufacturing, and the academies in turn should be, not only attentive to the demands, but aggressively exploring the present possibilities and probable future applications of the technology.

The same symposium also suggested that ". . . an in-depth study be made to determine whether present academic institutions can be utilized to provide CAM educational necessities expeditiously." With regard to our present educational programs, it stated that:

> Unless changes are effected in our educational processes by 1975 or 1980, it will become difficult, if not impossible, to obtain thoroughly qualified personnel through present educational processes (1967, p. 275).

As 1980 approaches the truth of the Symposium's prediction can be seen. In recent years, the proliferation of N/C equipment, once used only by the aerospace industry and now spreading to smaller shop applications, has increased the difficulty of providing qualified personnel for an increasingly sophisticated technology. It is estimated that by 1980, the sales of N/C machines will outnumber the sales of conventional machine tools. According to B.W. Ostrander:

> Pressures that have led to the acquisition of N/C machines will not diminish, so still more N/C machines will be in use in the future. Productivity must continually increase to meet rising costs and competition (1974, p. 436).

The fundamental issue is to realize that N/C machines are not just one more step towards automation but, coupled with the computer, represent a totally new manufacturing concept, compared by many authorities to the introduction of the assembly line and interchangeable parts. Accepting this new technology in our educational programs will require a reorientation of curriculum efforts and priorities.

From the point of view of manufacturing managers, the present curricula in the junior and senior high schools, and even in the engineering colleges, do not provide the background to be effective in the modern manufacturing industry. They conclude that much of the current curricula lacks a meaningful application to reality, (Pahde,

1975). Particularly technical-vocational education should accept the challenge of providing relevant instruction for industry-oriented students by incorporating the new technologies into their programs (Ostrander, 1974).

In its fifth annual report (1974, p. 89), the Advisory Council for Technical-Vocational Education in Texas recommended:

> . . . that industry be involved in teacher preparation programs and in updating skills, strengthening of relationships of employers and teacher preparation programs to improve realism of programs.

The State Board of Education accepted the Council's recommendations and supported the Council's industry-education personnel exchange. This action represents an effort to facilitate the updating of the technical competencies of technical-vocational teachers relating to new developments in modern manufacturing industries. Regarding the needs and resources in technical-vocational education, the Advisory Council also stated that: "Rather significant changes in job requirements and education in recent years have made traditional methods of communication and involvement obsolete" (1974, p. 9).

Educators and professionals in industry alike feel that the impact of numerical control and related technologies such as computer-aided manufacturing have been neglected by our educational institutions, Ted L. Pahde, President of Advanced Manufacturing Concepts (March, 1975) noted:

> There is a definite requirement for additional training in the effective use of numerical control for virtually all areas in the manufacturing organization. This includes top level management, design and manufacturing engineering, shop supervision, machine tool operators, and maintenance personnel.

The increasing application of numerical control technology and computer aided manufacturing represents a challenge, of particular interest to vocational, technical, and industrial education, to orient students to these new technologies. James C. Childs (1973, p. 27) summarized the position of many authorities in N/C when he stated:

> Automation, as well as progress, however, does have a price tag. In order to use it properly, one must be trained to meet its technical demands. Numerical Control, while outproducing conventional equipment, requires trained operators, maintenance personnel, and technicians (part programmers).

Apart from the recognized need for training of technicians in this technology, professionals in industry frequently suggest training seminars in management of N/C operations as well as planning for N/C facilities and equipment.

Current N/C Programs in Higher Education and Industrial Organizations

For the purpose of determining the present status of instructional programs in Numerical Control, in institutions of higher education, a preliminary survey was conducted among all participants of the APT-Education Agreement as of 1970. (See survey letters in Appendix A). The original list of educational members was published by the Illinois Institute of Technology Research Institute in 1967 and included 38 institutions of public education at that time. The most recent

membership list (1974) included over 50 universities, junior and community colleges, as well as vocational-technical schools.

The review of instructional materials, program guides, and course outlines, revealed a considerable variety, both in breadth and depth, of N/C-programs presently offered at various schools. However, the actual number of institutions with any significant course offerings in N/C was limited to universities in only eight states, and junior or community colleges in five states.

The number of N/C courses offered at universities ranged from 14 individual courses in one particular institution to a single course in several other institutions with only 50 percent of the course in N/C instruction. A detailed analysis of the individual course outlines and descriptions revealed equally varied course content material. However, the majority of the courses dedicated the major portion of time to manual part programming and a far smaller amount to computer programming for N/C.

As expected, most junior colleges were dedicated to specific N/C-technician or N/C programmer training, both in manual and computer programming. However, with the exception of few universities, a considerable lack of management-oriented instruction for N/C was noticed, particularly with respect to economics, equipment selection, and justification, and similar aspects of N/C. This was one of the

more noticeably emphasized areas in N/C-related training programs offered by various industrial organizations.

The second part of the literature survey reviewed program materials received from a number of industrial training, educational, and information services listed in the NC/CAM Guidebook (Modern Machine Shop, 1975, p. 122). Relevant material from industry included descriptions of N/C seminars, training courses, and information consulting services, as well as maintenance and specific equipment training. Apart from the expected training for manual and computer assisted part programming, presently offered by various equipment and control manufacturers, including professional organizations and societies, training in other N/C-related areas is frequently included. A considerable portion of industrial N/C-training programs appeared to be dedicated to such topics as equipment selection, evaluation, justification, plant layout, machinability data, and concepts of computer integrated manufacturing. The information gleaned from this literature revealed a number of additional areas of significance to instruction in N/C not previously emphasized in educational programs in public education. This additional information provided valuable input to the design of the NC/CAM Training Topic Inventory used in the nationwide survey of this study.

Related Research Efforts in Numerical Control Instruction

A considerable amount of recent literature in the field of curriculum development deals with the problem of selecting relevant educational content and developing effective instructional techniques. A number of research studies designed to identify appropriate instructional materials utilized survey-type questionnaires for follow-up studies of program graduates, opinionnaires to experts within a specific professional field, and/or similar data gathering methods. The first category of related research studies, which are mainly concerned with identification of requisite tasks and selection of appropriate curriculum content, include the following studies:

Trudeau (1972) conducted an industrial survey to determine the capabilities and functions of the technologist. He then used the data to develop a cooperative work education model for educational programs in industrial technology. The results of his study indicated considerable disagreement between industrialist's and educator's opinions concerning industrial technologist's tasks and competencies.

Botsford (1972), in a follow-up study of industrial technologist graduates, developed a work-task inventory and compiled detailed information on specific task and job requirements as a basis for the revision of the Industrial Technology curriculum at Texas A&M University.

In a comparative study between selected industrial personnel and educators in industrial education departments, Case (1971) investigated

the status and application of computer graphics in industry and its implications for college level drafting curricula. As expected, the findings showed that insufficient funds and the lack of facilities limited the number of industrial arts teacher education institutions offering computer graphics, even though a definite need for trained industrial personnel in this area was identified.

Walston (1970) conducted an industrial survey to determine essential requisites for employment in drafting and design occupations. The objective was to develop a planning guide for technology programs in these fields in Texas junior colleges. A detailed planning document resulted from the study, incorporating industrial specifications and employment requisites for the implementation of such programs in two-year post-secondary educational institutions.

The reviewed literature, specifically related to instructional programs in numerical control technology, can be generally classified into one of two broad categories. The first category relates mainly to research studies concerned with the selection of appropriate content material for curriculum development and training requirements. The second category is concerned with instructional methodology, such as the multi-media approach, teaching methods, and simulation techniques. The first category includes the following studies:

Leeth (1973) conducted a study to identify the current status of numerical control technology and computer aided manufacturing in Texas industries, and the present and future needs for training

programs in these new technologies. Through personal interviews with 34 industrial representatives, the present NC/CAM applications in various Texas companies were identified. The results of this study identified a definite need for training programs in the area of numerical control technology at the vocational-technical high school level, the junior and community college level, and in other institutions of higher education.

A study at the University of Maryland by Campbell (1971) intended to develop specific content material, in the form of descriptive data, concerned with numerical control. A data gathering instrument was submitted to 25 industrial experts in N/C, soliciting their opinions with respect to 12 major elements in 4 categories of numerical control, specifically (1) Input, (2) Processing, (3) Programming, and (4) Control Equipment. The result of the study showed substantial agreement among the respondents concerning these elements as representative of the body of knowledge in numerical control technology.

A research study at the University of Michigan by Medeiros (1970) examined the implications of numerical control machines for vocational education. This study compared the skills and knowledges needed by machine tool operators and maintenance workers on conventional machines with those needed by personnel on numerical control machines. This study also included an analysis of possible implications for general education as well as the need for change in present machine shop courses in vocational education. Through an in-plant job analysis and

interviews with supervisors, foremen , and training directors, specific job requirements were determined. The resulting research data revealed a shift in emphasis from manual skills to mental skills, with the application of numerical control requiring retraining of machine operators. It was also suggested that the vocational and technical schools provide basic courses for machine operators and machine maintenance men.

Patterson (1967) in a study investigating current metals programs in the secondary schools suggested a new curriculum for machine tool technology. The significance of this study was that, apparently for the first time, basic principles of N/C, manual programming, and applications of N/C were included in a secondary vocational-technical metals program in Texas.

The second category of research studies, which are mainly concerned with instructional techniques such as simulation and multi-media approaches to teaching N/C, include the following studies:

Olling (1974) conducted a study entitled: "Teaching Numerical Control Part Programming principles (Machining): Computer versus Instructor Program Verification". The purpose of this investigation was to compare two methods of teaching computer assisted part programming principles, namely: (1) computer assisted program verification, and (2) instructor verification. The analysis of the data of this experimental research revealed no significant difference in achievement or performance, which implies that both methods are equally effective

in teaching computer assisted numerical control part programming.

In a recent study by White (1974), the implications of numerical control electronic systems maintenance for engineering technology programs was investigated. A N/C systems maintenance course syllabus was developed and its content validity determined by 29 machine tool builders and 39 N/C equipment users. Subsequently, a systems maintenance laboratory was taught utilizing N/C machine tools as well as a simulated N/C system. A simple control group experiment indicated that simulated N/C equipment, which requires a considerably smaller capital investment, appeared to be adequate for teaching N/C control maintenance courses.

Pine (1973) researched the effects of teaching N/C concepts using a simulator in a high school industrial arts program. A multi-media instructional unit of numerical control technology was compared with conventional laboratory activities in order to determine the effects of both on understanding of N/C concepts, program writing efficiency, and general student attitude towards the two teaching methods. A 49-item achievement test, a programming problem, and a 47-item instructional attitude inventory were used to assess the respective criteria. The experiment did not reveal any significant difference between the conventional and simulated approaches to teaching numerical control at the high school level.

A study by Biekert (1971) was similarly concerned with comparing two methods of teaching N/C manual programming, one based on visual

media and the other based on actual hands-on equipment experiences. This experimental study intended to determine any differences in N/C achievement, programming performance, or general interest in N/C between the two control groups. Over a period of 6 weeks, two groups of students were exposed to the two different teaching approaches. A three-part criterion instrument measured achievement, performance, and interest of both experimental and control groups. It was concluded that both groups performed equally effectively, with no significant difference in achievement, performance, or interest between the two treatment groups.

Another study by Rummell (1971) investigated the potential value of low-cost simulation versus high-cost equipment as an effective instructional technique in teaching numerical control principles. The conclusions reached from this experimental study were similar to the previous one in that both simulation and actual utilization of N/C equipment were equally effective in achieving basic knowledge, developing program writing proficiency, and developing positive attitudes towards numerical control.

Finally, an experimental study by Umstattd (1970) developed a complete unit on instruction in N/C manual part programming. He utilized a multi-media approach to teach point-to-point part programming under simulated conditions. The results of the study were significant in that N/C manual part programming could be taught by incorporating a simulator approach into the conventional instructional

programs. The N/C simulator teaching aid designed during this research proved as effective as hands-on experience in demonstrating basic N/C principles. The simulator provided an economic means for practice in programming principles, thus reducing, to some extent, the high cost of N/C instruction.

CHAPTER III

RESEARCH METHODOLOGY

While previous research investigating the status of numerical control dealt with either industry (Leeth, 1973) or education (Patterson, 1967, Medeiros, 1970) this research study intended to investigate both through a nationwide survey of industrial and educational institutions involved in N/C technology. By comparing the opinions of industrialists and educators, this study proposed to determine the changing requirements for N/C programs in industrial education and technology. The specific objectives of this study were twofold: (1) to determine the present status of the post-secondary educational programs in numerical control, and (2) to determine the task requirements for industrial personnel in the field of computer aided manufacturing.

The sequence of the various research activities is illustrated in Figures 1 and 2 which divide the total project into two phases: (1) survey preparation and instrument development, and (2) data collection, compilation, and analysis.

Selection of the Survey Sample

The survey population consisted of two major samples: (1) participants from educational institutions at the post-secondary level (2) participants from industry, specifically N/C users. In

FIGURE 1

DEVELOPMENT OF RESEARCH ACTIVITIES IN PHASE I OF PROJECT

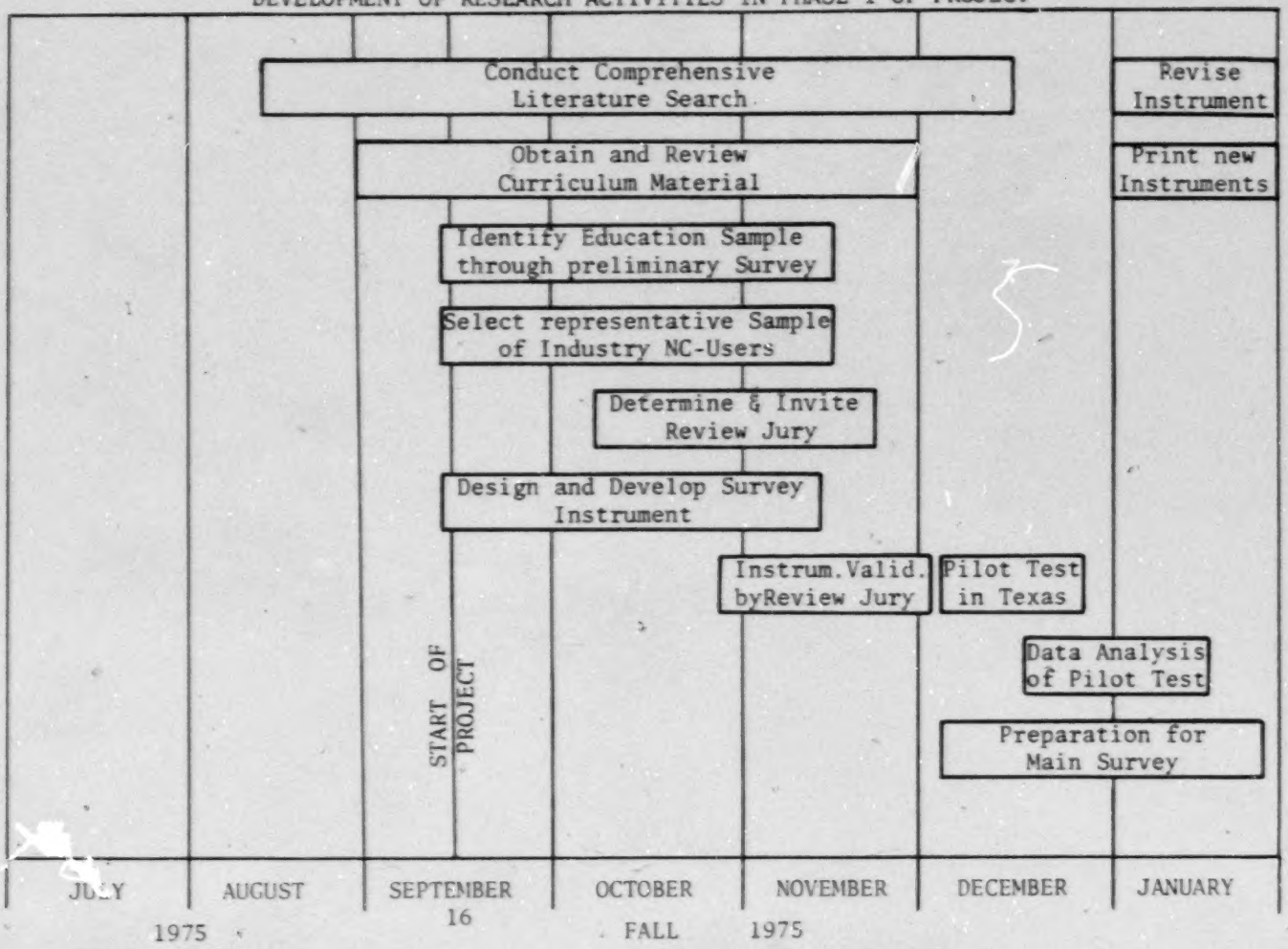
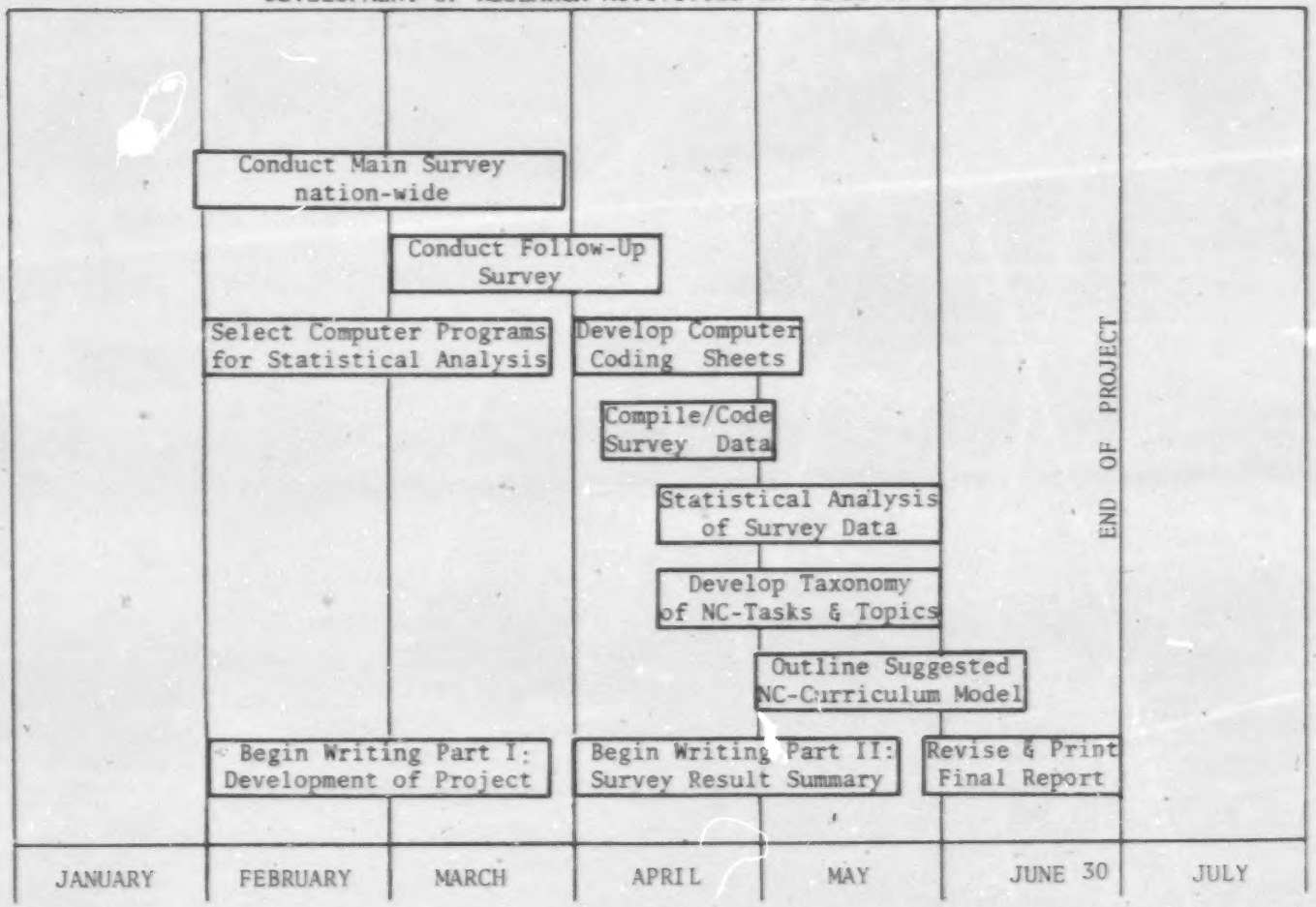


FIGURE 2

DEVELOPMENT OF RESEARCH ACTIVITIES IN PHASE II OF PROJECT



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order to identify an appropriate representative sample, it was decided to include three main groups among post-secondary institutions: (1) ACIATE-industrial teacher education institutions, (2) ECPD-accredited engineering technology institutions, (3) TEA-occupational technical programs in post-secondary institutions in Texas, and (4) occupational technical programs in junior and community colleges from out-of-state.

Since the final survey was specifically intended for instructors directly involved in N/C programs at the various institutions, it was necessary to separate those institutions with programs from those without programs. In the case of industrial teacher education institutions, the ACIATE 1975-76 membership directory was used and a letter of inquiry was mailed to all 246 institutions. In the case of engineering technology programs, 56 ECPD-accredited institutions were contacted in order to identify all technical programs with N/C instruction. For Texas junior and community colleges, the 1974-75 TEA information guide and directory of occupational technical programs in post-secondary institutions in Texas was used. According to this directory, a total of 63 two-year institutions were identified. Thus, a total of 365 post-secondary institutions were asked to indicate the names of persons who are teaching N/C technology courses or who are developing curriculum in this area. (See letter in Appendix A).

Table 1 lists the three types of educational institutions contacted, the number of those presently offering N/C programs, and the

TABLE 1

IDENTIFICATION OF EDUCATIONAL SURVEY SAMPLE
THROUGH PRELIMINARY SURVEY

Educational Institutions	Inquiry Mailing	Present N/C Programs		Future Plans	
		N	%	N	%
ACIATE - Industrial Teacher Education Institutions (4-year)	246	64	26	40	16
ECPD - Accredited Engineering Technology Institution (4-year)	56	6	11	14	25
TEA - Occupational-Technical Programs in Post-Secondary Institutions in Texas (2-year)	63	6	10	14	22
Occupational-Technical Programs at Junior and Community Colleges Out-of-State (2-year)*	(22)	(22)	--	--	--
TOTALS	365	76	21	68	19

*NOTE: 22 Out-of-State two-year institutions were selected from college catalogs with known N/C - instructional programs. Total Survey Participants: 76 Present N/C programs plus 68 future programs plus 22 two-year programs. 166 Total.

number of those planning to have future courses in this area. In addition to these three groups, 22 out-of-state two-year institutions were selected from college catalogs with known N/C instructional programs.

For the selection of the industrial survey sample, it was decided not to randomly select a specific percentage from the total number of manufacturing enterprises in the United States, but rather, to contact the specific group of N/C users and individuals that are actively involved in numerical control in industry. In order to identify a selected group of N/C users among the large number of manufacturers, it was necessary to approach certain professional organizations and societies which would have particular interest in this field. It was decided to contact the following professional organizations: (1) the Numerical Control Society (NCS), and (2) Computer Aided Manufacturing-International Inc. (CAM-I), to request their cooperation and obtain the necessary membership directories.

Table 2 lists the two professional societies and the respective number of participants which, in the case of the N/C society, were limited to all company members and representatives as well as individual members in the United States. All educational, student, and society members outside the United States were excluded from the industrial survey sample.

From the 26 industrial CAM-I company members, one management representative per company and one technical representative per

TABLE 2

IDENTIFICATION OF INDUSTRIAL SURVEY SAMPLE
FROM MEMBERSHIP DIRECTORIES

Industrial Survey Population	Membership * Categories incl.	Participants	
		N	%
NCS - Numerical Control Society Professional Membership (1976 Directory)	Company Members and Representatives, Individual Members in the United States.	1704	85
CAM - I, Computer-Aided Manufacturing - International, Inc. (1975 Directory and Basic Program)	1 Management Representative	26	81
	1 Technical Representative per Company	26	81
Total Sample		1756	84.88

*NOTE: Not included in the industrial sample were educational and student members, and society members outside the United States.

company were selected, adding 52 survey participants to the industrial group. Thus, a survey population of 1,756 individuals was identified from the two professional organizations in the specified membership categories.

Preliminary Curriculum Material Survey and Review

In order to obtain and review the most current material relevant to the field of N/C technology, it was decided to conduct a preliminary survey among selected universities with known N/C programs. Also, a selected number of training and consulting services in industry as well as related professional societies, publishers, and other institutions with particular interest and expertise in the field of numerical control were identified for this preliminary survey. (See letters in Appendix B).

The purpose was to research and review the most current instructional and educational programs in N/C, both in higher education and in industrial training institutions. As a result of this inquiry, a considerable amount of curriculum material was received from more than 30 different institutions. Subsequently, all material was reviewed together with pertinent text books in the area and a preliminary list of the most important and most frequently occurring curriculum elements was compiled. A comprehensive review of the current professional literature, together with the obtained curriculum material from education and industry, provided the foundation for the subsequent development of the survey instrument.

Design and Development of Survey Instrument

In order to identify which competencies and tasks should be included for future curriculum development in this area, a questionnaire was developed. To guarantee a common reference base for comparing the results, this instrument had to contain items that would be appropriate for both educational and industrial survey participants. Therefore, it was decided to divide the survey questionnaire into two parts: Part I (different for education and industry) requested specific descriptive information concerning their respective situations, and; Part II (identical for both education and industry) consisted of the NC/CAM Training Topic Inventory. Criteria for the design of the survey questionnaire were simplicity in answering, directness, and relevancy to the educator as well as to the N/C user in industry.

Since Part I of the instrument referred to general information regarding the educational institution or the particular company, it was necessary to develop a separate form to provide for the different environments of these two populations. The first part of the industrial questionnaire was subdivided into five sections to facilitate responses. Section I requested identification of the respondent, including his position and the location of his company with a note indicating that all information would be treated confidentially and only in summary form. Section II requested specific information about the respondent (educational background, and main work area), and

general data concerning the total number of employees in the plant as well as the number of N/C related personnel. Section III referred specifically to the type of N/C machines and controls in use, and the number of units installed in the particular plant, as well as the type of programming technique used. Section IV inquired about the different sources for the training of N/C personnel in the company and the estimated number of new personnel to be employed within the next five years. Finally, the last section V asked the respondent to identify his company's main line of business and future plans for purchasing additional N/C machines. Provisions were also made for additional comments and general information.

The educational version of Part I was also subdivided into five sections. However, where sections I and II of the industrial form referred to plant personnel, the educational form requested information regarding faculty size, student enrollment, and main teaching area of the respondent, as well as his background in N/C. Section III was almost identical to the industrial version except for the requested listing on non-N/C machine tools. Section IV referred to the level of courses, their duration, and student course enrollment. The last section V requested estimates of machine tool acquisitions in the particular educational institutions over the next five years. (Both forms of the questionnaire are included in Appendix G).

Part II, which was the same for both groups, consisted of the NC/CAM Training Topic Inventory, representing a comprehensive list of

tasks and topics in several major areas of numerical control and computer aided manufacturing that may be included in an educational training program. This list of training topics was derived from previously reviewed curriculum materials and professional literature, in consultation with the advisory committee. It was decided to request the respondent's opinions concerning the importance of these items, based on a five point Likert Scale with a value of 5-great importance, 4-substantial importance, 3-moderate importance, 2-limited importance, 1-no importance.

Educators were asked to indicate the relative importance of each topic in their educational program. Similarly, industrial representatives were requested to indicate their opinion as to the relative importance that each topic should have in educational programs based on the requirements of their type of business or industry. (The complete list of items is indicated in the survey instrument included in Appendix G).

Instrument Validation by Jury

For the purpose of establishing face and content validity of the survey questionnaire, a professional jury was selected. These jury members, from both education and industry, were identified on the basis of their professional expertise in the area of N/C, as well as their representativeness of the two survey samples. For this reason, four members were invited from the educational community representing two-

and four-year institutions, including industrial education, engineering technology and vocational-technical programs. The educational jurors came from the following post-secondary institutions: (1) Arizona State University, Tempe, Arizona; (2) Bradley University, Peoria, Illinois: (3) Texas State Technical Institute, Waco, Texas; (4) Washtenaw Community College, Ann Arbor, Michigan.

From the industrial sector, the following individuals were invited to participate on the validation jury: (1) The Manager of Manufacturing Research at Cincinnati Milacron, Cincinnati, Ohio: (2) the President of Advanced Manufacturing Concepts, Florissant, Missouri: (3) the Manager of N/C Support, Cameron Iron, Houston, Texas; and (4) the President of J. A. Moorehead Associates, N/C Consulting Services, Lawrence, Kansas. (See list of jurors in Appendix D).

Since all individuals contacted accepted the invitation to participate on the validation panel, they received a preliminary survey questionnaire with the following request:

> Please express your opinion regarding the relevancy and validity of the following N/C topics for educational training programs by checking "Yes" if the item should be included in the final survey questionnaire and "No" if it should be deleted (Letter, Appendix C).

The questionnaire items were selected and compiled on the basis of the preliminary survey results from both industry and education, including two-and four-year post-secondary institutions. Consequently, they are not limited to a particular job, but rather propose to cover the various areas of numerical control technology. It should also be

emphasized that no single educational course includes all 98 topics, nor does any industrial position require knowledge of all five main areas. However, the great variety of work tasks and requirements of personnel working in NC/CAM related areas requires consideration of all topics included in the instrument.

Therefore, it will be the responsibility of the individual educational institutions at different levels and program orientations to select from the survey results only those elements which are most appropriate for their particular objectives and levels of educational programs.

The main purpose of the validation process was to refine the questionnaire for clarity, relevancy, and eventually for better communication with the respondents in education and industry. The review by the eight jury members resulted in general agreement over the inclusion of the original 155 items in the preliminary questionnaire. Only six questions were deleted and eight questions were added, bringing the total to 157 after the jury validation process (See jury form for education and industry in Appendix E).

Pilot Testing of the Survey Instrument in Texas

Following the changes and revisions in the original questionnaire, it was then decided to pilot test both versions (education and industry) at the state level in two major metropolitan areas in Texas--Houston and Dallas. For that purpose, several questionnaires were distributed

at the Annual Convention of CAM-International in Arlington and the Houston Chapter meeting of the N/C-Society in Houston. Similarly, several educators were personally interviewed at a number of post-secondary educational institutions in Texas.

As a result of this field test, the format of the two versions of the questionnaire was changed in order to facilitate responses. After consultations with the project advisory committee, it was decided to reduce the overall number of 157 items in eight major content areas to a combined total of 98 items in only five different areas. This decision was justified on the basis of overall brevity and a better potential for a more representative number of returns.

Based on extensive statistical analysis of the pilot test results such as frequency of responses, item analysis, and importance rankings of all questionnaire items, it was decided by the project advisory committee to delete those items which ranked with no or limited importance. However, only twelve items were deleted and another 47 items were combined with other items.

Thus, the final survey instrument consisted of 98 individual items, divided into five major areas of NC/CAM which were: (1) Basic N/C Concepts, (2) Manual Programming, (3) Computer Assisted Programming, (4) Management Aspects, and (5) Advanced Technologies. (The final questionnaire is included in the Appendix G).

Collection and Statistical Analysis of Data

As illustrated in Figure 2, the collection and analysis of data took place during Phase II of the research. In order to facilitate responses by the survey participants and identification and coding by the researcher, the instruments were designed with subsequent computerized statistical data analysis in mind.

The two types of questionnaires were printed front and back on blue (education) and yellow (industry) oversize (25 1/2"x 11") sheets respectively, thus containing information of six regular letter size sheets on a single, trifold form. All instruments were mailed with a cover letter explaining the purpose of the survey and the type of information requested. (See letters in Appendix F) together with a self-addressed, postage-paid return envelope. A follow-up of all non-respondents was conducted after a period of four weeks consisting of a reminder letter and an additional questionnaire form and return envelope. The substantial increase in the number of returns after the follow-up can be attributed to this measure.

During the four week period between the first and second mailing, a computer coding system was developed, based on the returns from the initial survey. A separate identification code for the industrial and educational responses was designed, allowing subsequent classification of subgroups within the two major survey populations. The

subgroups for industry follow:

(1) Industry types by Standard Industrial Classification Code SIC,

(2) Occupational position of company respondent,

(3) Geographic location of responding Companies by state,

(4) Company size according to number of employees per plant.

Similarly, a code sheet for data input of the educational responses was implemented in the following manner:

(1) Type of institution according to educational program type and duration,

(2) Status of N/C-instructional programs,

(3) Position of faculty respondent,

(4) Geographic location of responding institutions of higher education,

(5) Department size according to number of full-time faculty.

(See Appenidx J for Input Data Code Sheets for Educational and Industrial Responses).

The statistical analysis of the survey data was accomplished by utilizing the following statistical package available at the Texas A&M University Data Processing Center: Fortran Programming for the Behavioral Sciences by D.J. Veldmann, (1967), revised by D.G. Barker, Texas A&M University, 1971.

The specific statistical routines selected for a particular analysis, such as descriptive statistics, item analysis, frequency distribution and analysis of variance are identified and referred to in Chapter IV.

Concept Identification and Development of Curriculum Model

Based on a detailed statistical analysis of all survey data, including a comparison of responses between the industry and education groups, the most important N/C concepts were identified. Part II of the survey instrument provided the data base for this analysis in the form of the comprehensive NC/CAM Training Topic Inventory. The ratings of relative importance for each of the 98 items, as well as for each of the five main areas combined was calculated and compared between the two main responding groups. A choice distribution, item analysis, and frequency distribution, together with an item and rank ordered listing of response values served as a basis for the identification of N/C tasks and topics with the highest importance ratings. A suggested curriculum outline, in the form of a listing of priority areas for future detailed curriculum development for N/C-instructional programs, was derived from the final analysis of the NC/CAM Training Topic Inventory. For that purpose, an analysis of variance of responses between industry and education determined significant differences in responses.

The final listing of content material that may be included in new curricula was selected on the basis of importance ranking by both industry and education. The overall rating of each item was thus determined by the relative importance that each topic should

have in educational N/C programs based on the actual educational requirements of industry and the conceptions of educators knowledgeable in this field.

The end result of this comprehensive analysis of both industrial and educational responses to the original NC/CAM Training Topic Inventory was a suggested listing of major curriculum elements in five individual areas. This list was summarized in the form of a suggested curriculum outline of N/C topics serving as a guide and reference for detailed program development in numerical control technology and computer aided manufacturing.

CHAPTER IV

ANALYSIS AND PRESENTATION OF DATA

One purpose of this research was to identify a data base for curriculum development in Industrial Education and Technology relevant to the present status of N/C technology and computer aided manufacturing in American industry. Based on the proposed research design, the required data was collected through a nationwide survey of industrial organizations and educational institutions.

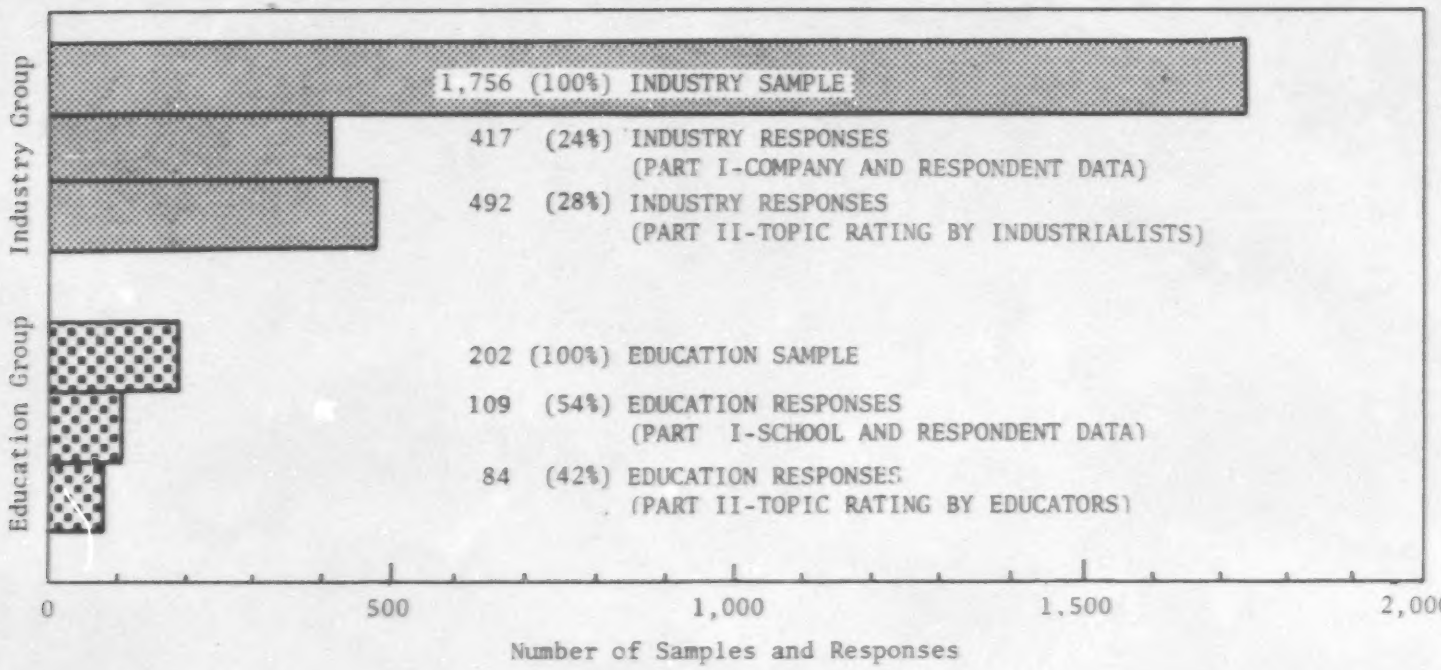
Distribution of Survey Samples and Responses

The survey population consisted of the following two groups: (1) educators from post-secondary institutions and (2) N/C-users from industry. The survey instrument administered to each group was divided into two major parts. Industry's Part I pertained to the descriptive information regarding the present status of NC/CAM in American industry, while the educator's Part I referred to the current status of NC/CAM curriculum in industrial education and technology. Part II, common for both survey groups, was the NC/CAM training topic inventory providing data for a comparison of the industrial and educational positions on required tasks and topics for educational programs in NC/CAM.

Figure 3 illustrates the distribution of the two main groups surveyed with their respective sample sizes. The industrial sample

FIGURE 3

DISTRIBUTION OF SURVEY SAMPLE AND COMPLETED RESPONSES TO THE SURVEY INSTRUMENT
(PART I: COMPANY, SCHOOL, AND RESPONDENT INFORMATION, PART II: NC/CAM TRAINING TOPIC INVENTORY)



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consisted of 1,756 participants (90 percent of the total), and the educational sample consisted of 202 participants (ten percent of the total). The returns of 627 represented 32 percent of the total 1,958 questionnaires mailed to both groups. Figure 3 also illustrates the individual number of responses by groups to Parts I and II of the survey instruments. While only one questionnaire per company provided data for the descriptive Part I, the training topic inventory Part II was analyzed by individual respondents.

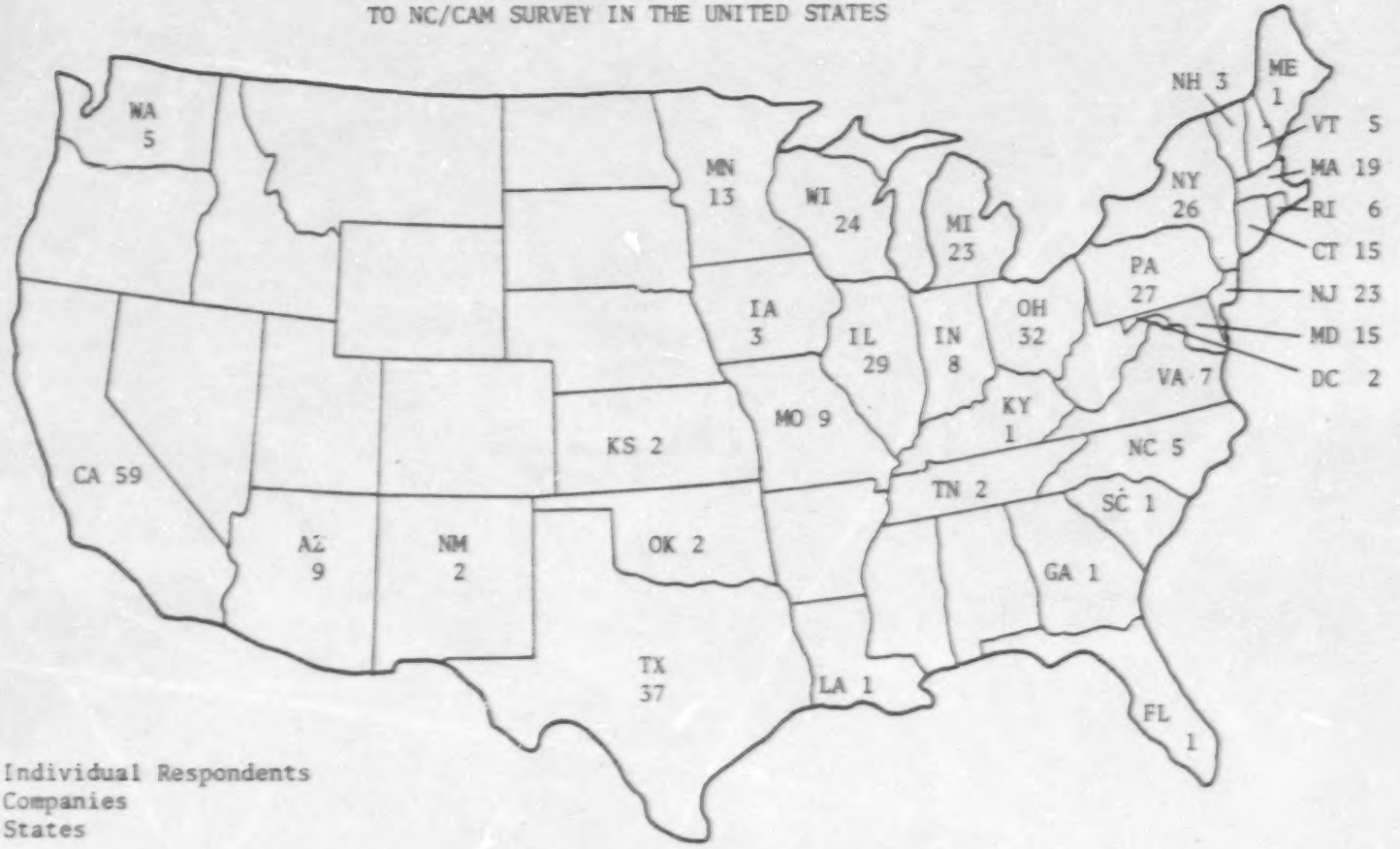
Therefore, of the 1,756 companies surveyed, 502 individual responses were received from 423 different companies. Of these 423 companies, 417 (24 percent of the industrial sample) were completed correctly for Part I. Of the 502 responses to Part II, 492 (28 percent of the original industrial sample) were completed correctly. In contrast, of the 125 responses from educational institutions, 109 (54 percent of the educational sample) were received completed for Part I, and 84 (42 percent of the educational sample) were returned completed for Part II.

Distribution Characteristics of Industrial Responses

The 417 companies represented 34 states nationwide. However, as expected, the majority was received from only thirteen states. Figure 4 graphically illustrates the distribution of responding companies across the United States. The thirteen states contributing

FIGURE 4

LOCATION OF COMPANIES RESPONDING
TO NC/CAM SURVEY IN THE UNITED STATES



492 Individual Respondents
417 Companies
34 States

81 percent of the returns are in rank order as follows: (1) California, (2) Texas, (3) Illinois, (4) Ohio, (5) New York, (6) Michigan, (7) Pennsylvania, (8) Wisconsin, (9) New Jersey, (10) Massachusetts, (11) Connecticut, (12) Maryland, and (13) Minnesota. Each of the remaining 21 states returned fewer than ten responses.

In order to obtain a more detailed breakdown of industrial responses, a distribution of companies by industry according to the Standard Industrial Classification Code was compiled (See Figure 5). Forty-seven percent of the companies were from Group 35-Machinery Except Electric. The second largest was Group 37-Transportation Equipment, representing fifteen percent. The next two groups with thirteen percent each were 36-Electric and Electronic Equipment, and 60-Administrative and Auxiliary, which included sales, service, and software manufacturers.

The largest group of respondents (sixteen percent) came from companies having 1-24 employees. The next most frequently represented group of companies (fifteen percent) were in the 250-499 employee category. The third largest, fourteen percent of the total, employed 500-999 persons; and the fourth ranking group, representing thirteen percent of companies responding, had 100-249 employees.

Table 3 illustrates the distribution of all completed survey instruments received from industry according to the position of the company respondent. This breakdown again uses the seven main groups

FIGURE 5

INDUSTRIAL SURVEY RESPONSES BY TYPE OF INDUSTRY AND SIZE OF COMPANY

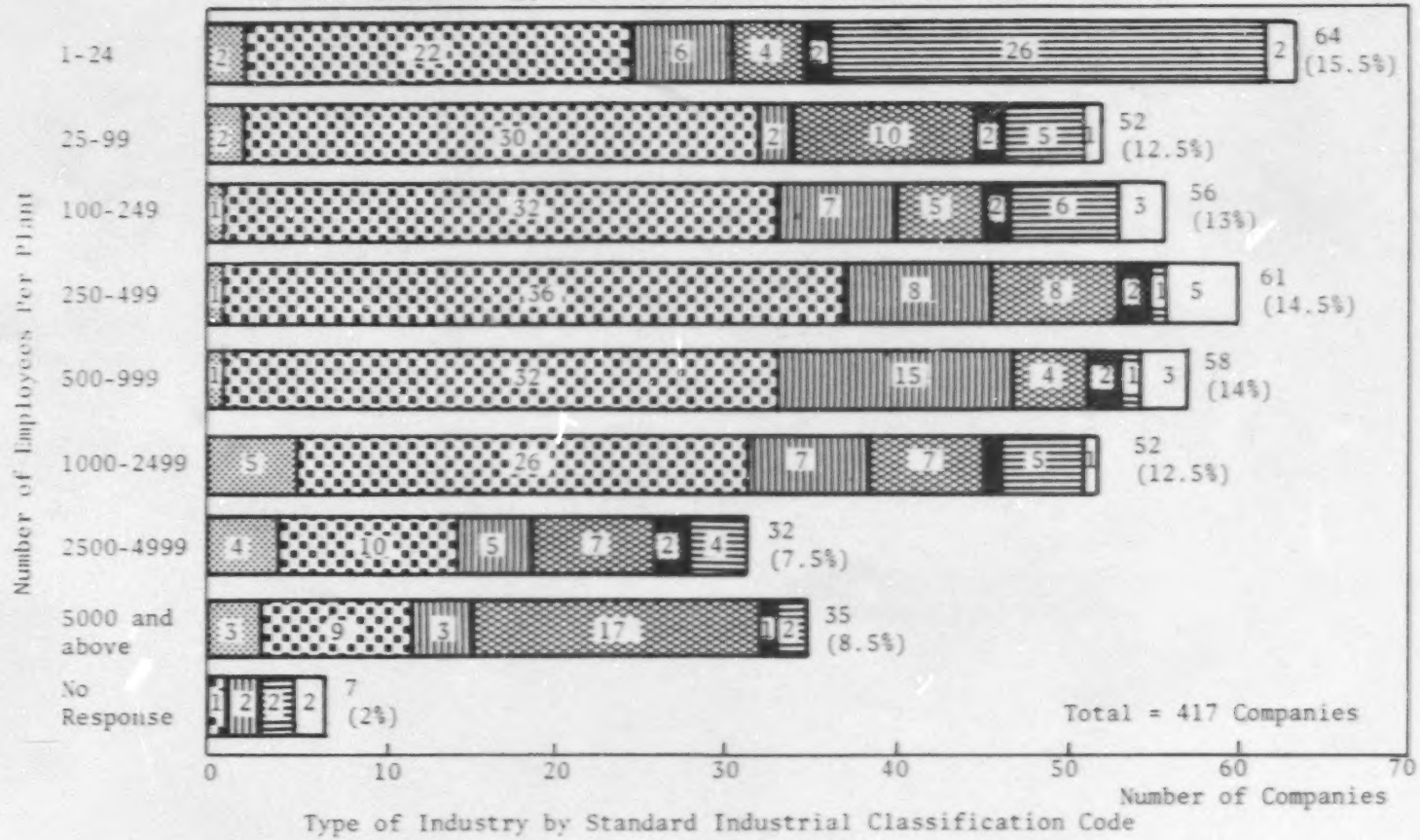


TABLE 3

INDIVIDUAL SURVEY RESPONSES BY POSITION OF COMPANY RESPONDENT

	No Response	President Vice-Pres.	Manager Production	Manager Sales	Director	Supervisor Production	N/C. Programmer	Engineer	Technician	Owner	Total Number & Percentage
34 Fabricated Metal Products	3	0	2	0	1	0	6	6	0	0	18 (4%)
35 Machinery exc. Electric	35	18	26	2	3	16	92	48	1	3	244 (49%)
36 Electric & Electronic Equipment	7	4	9	0	1	4	21	18	0	0	64 (13%)
37 Transportation Equipment	6	6	8	0	2	3	33	13	2	1	74 (15%)
38 Instruments & Related Prod.	4	1	1	0	0	1	4	4	0	0	15 (3%)
60 Administrative & Auxiliary	3	14	5	6	1	3	12	13	0	3	60 (12%)
01 Others, not Classified	6	2	3	0	1	0	1	4	0	0	17 (4%)
Total Number and Percentage	64 (13%)	45 (9%)	54 (11%)	8 (1.8%)	9 (2%)	27 (6%)	169 (34%)	106 (21%)	3 (.6%)	7 (1.6%)	492

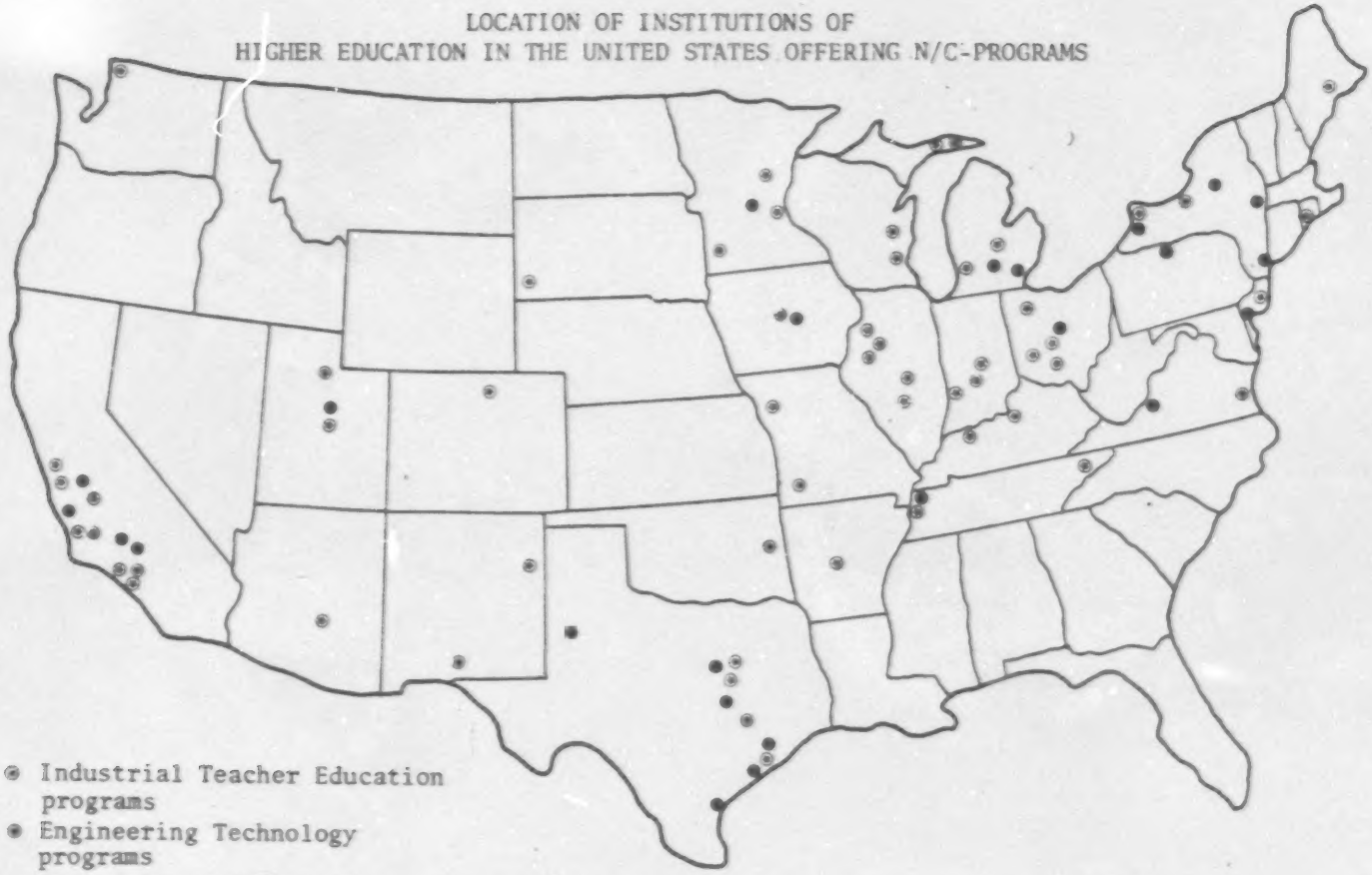
of industries and illustrates the distribution of nine of the major position categories as follows: (1) Owner, (2) President or Vice-President, (3) Manager (Production), (4) Manager of Sales, (5) Director, (6) Supervisor, (7) N/C Programmer, (8) Engineer, and (9) Technician. As expected, the largest percentage of returns (34 percent) came from the group of N/C programmers. The second largest group responding was engineers (21 percent), followed by managers of production (eleven percent), and presidents or vice-presidents of companies (nine percent). This breakdown by respondent's position and industry type was investigated further in order to determine any correlational relationships of respondents with their responses to the NC/CAM training topic inventory. Other independent variables for this correlation analysis were the location and size of company.

Distribution Characteristics of Educational Responses

Figure 6 shows the location of participating educational institutions currently offering educational programs in numerical control in the United States. Of all the institutions responding to the survey, 46 industrial teacher education institutions are presently offering instruction. Eleven engineering technology departments and 24 junior colleges are also involved in educational programs in numerical control. This map illustrates the distribution of these institutions in 26 states with 40 percent of them concentrated in California, Texas, Illinois, and Ohio.

FIGURE 6

LOCATION OF INSTITUTIONS OF
HIGHER EDUCATION IN THE UNITED STATES OFFERING N/C-PROGRAMS



46 ◉ Industrial Teacher Education programs

11 ● Engineering Technology programs

24 ● Occupational-Technical programs

62

Figure 7 indicates that three of the fifteen four-year industrial teacher education institutions in Texas currently offer N/C programs. The map also shows the location of six of the 63 two-year post-secondary institutions in Texas currently involved in N/C instruction.

Figure 8 presents a breakdown by the type of institutions and the size of departments as indicated by the number of full-time faculty. The three main types of educational survey participants included industrial arts teacher education departments, engineering technology departments, and junior colleges offering occupational technical programs. This distribution indicates that 64 (59 percent) of the responses came from industrial arts departments, eighteen (sixteen percent) from engineering technology departments, and the remaining 27 (25 percent) responses were received from junior colleges. The largest group of departments responding (27 percent) had 1-3 full time faculty members per department, the second largest (26 percent) had 4-6 faculty members and the third largest group of respondents (nineteen percent) came from departments with 11-15 full-time faculty members.

Finally, Table 4 represents the distribution of responses by the position of the individuals responding from education and the type of educational institution. Of the 109 faculty responses, 58 percent were from industrial arts, 21 percent from engineering technology, and 21 percent from junior colleges. This distribution lists six major

FIGURE 7

LOCATION OF INSTITUTIONS OF
HIGHER EDUCATION IN TEXAS OFFERING N/C-PROGRAMS

FIGURE 8

EDUCATIONAL SURVEY RESPONSES BY TYPE OF PROGRAM AND SIZE OF DEPARTMENT

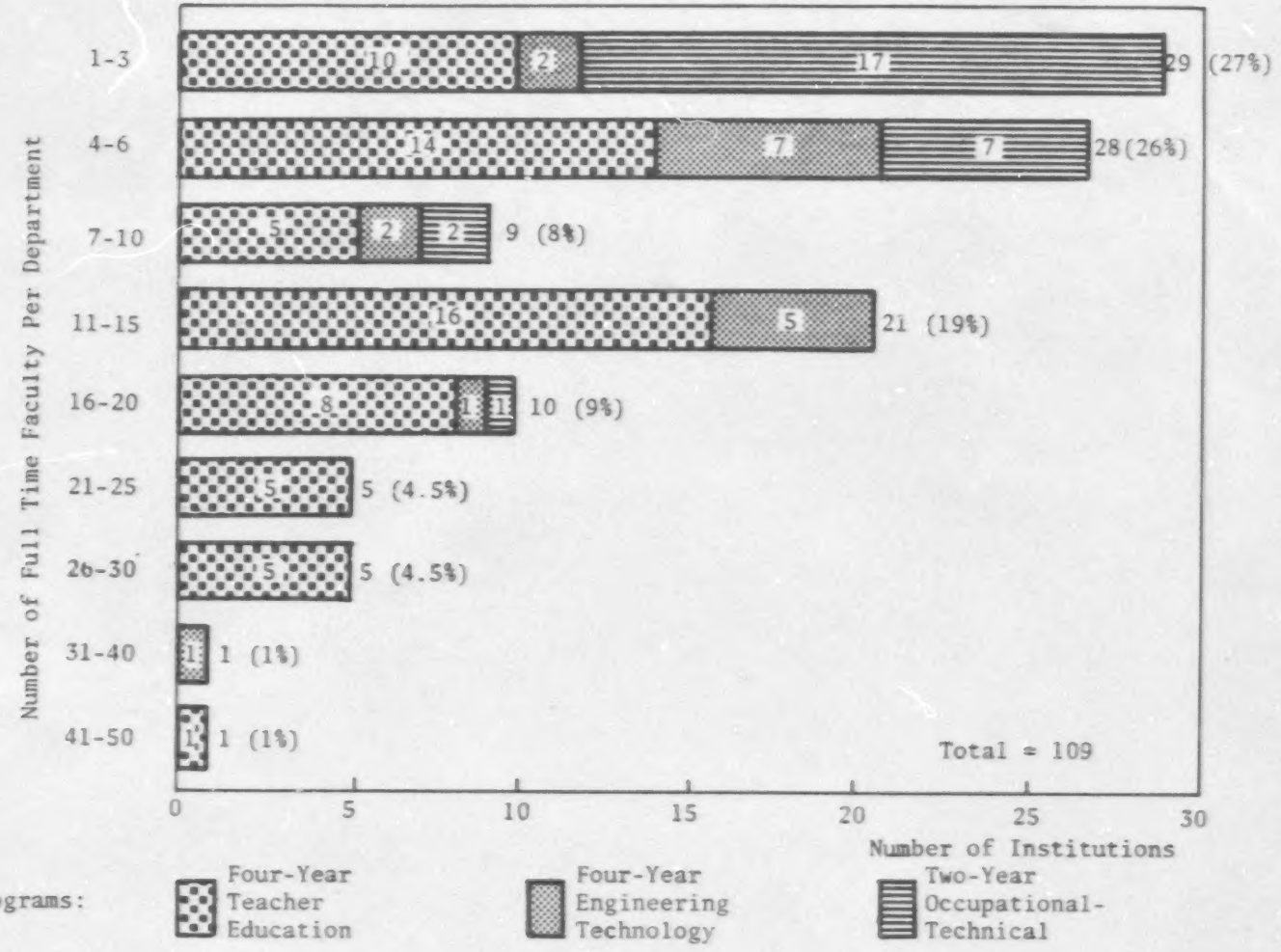


TABLE 4

INDIVIDUAL SURVEY RESPONSES BY POSITION OF EDUCATIONAL RESPONDENT

Type of Institution	Instructor	Assistant Professor	Associate Professor	Professor	Division Chairman or Director	Department Chairman or Head	No Response
Industrial Arts	9	21	15	4	4	10	0
Engineering Technology	2	3	6	3	2	4	3
Junior College	10	3	1	2	3	2	2
Total Number and Percentage 109 (100%)	21 (19%)	27 (25%)	22 (20%)	9 (8%)	9 (8%)	16 (15%)	5 (5%)

categories of faculty positions: Instructor, Assistant Professor, Associate Professor, Professor, Division Chairman or Director, and Department Chairman or Head. The largest response rate (25 percent) was from the group of assistant professors, the second largest (20 percent) came from the associate professor category and the third (nineteen percent) from instructors.

The Status of NC/CAM in American Industry

One of the objectives of this research was to investigate the present status of numerical control technology and computer aided manufacturing in American industry. In order to obtain relevant information on present utilization of N/C equipment, sources of training for N/C personnel, and present and future estimates of employment for trained and qualified individuals, specific data had to be compiled.

Part I of the survey instrument not only provided specific background information about the respondent, but also listed the present number and percentages of N/C personnel in different companies according to the following categories: machine operators, maintenance personnel, supervisors, and programmers. Part I also provided detailed information on current N/C machine tool types, utilization methods, types of control, and types of axes of N/C machines, as well as projections for new machines to be purchased in the foreseeable future.

Figure 9 provides background information on the industrial respondents by illustrating the main work areas in average number of years experience. Production was the first main work area, showing an average of 8.5 years work experience. Tooling/set-up was second with 7.4 years average and the programming field was third, showing an average of 7.2 years work experience. The general distribution of the main work areas shows the broad background of the industrial respondents, thus confirming their competency to assess the entire spectrum of N/C topics.

Present and Projected Numbers of N/C Personnel

Table 5 illustrates the average number of currently employed N/C personnel per plant organized according to the seven major types of industries from which responses were received. A total of 10,897 individuals directly related to numerical control operations were reported to be employed by the 417 companies responding. Of these, the major category, N/C machine operators, numbered 6,883 (63 percent) of the total), N/C maintenance personnel 1,434 (thirteen percent of the total), N/C supervisors or coordinators 674 (six percent of the total), and N/C programmers 1,906 (eighteen percent of the total).

Table 6 presents data on the average estimated number of new personnel in the area of numerical control for the next five years. Data for this distribution by types of industry was provided by 57 percent of the respondents. In contrast to present N/C personnel, this table breaks down the category of N/C programmers into three subgroups:

FIGURE 9

DISTRIBUTION OF MAIN WORK AREAS OF RESPONDENT
(AVERAGE NUMBER OF YEARS PER INDIVIDUAL)

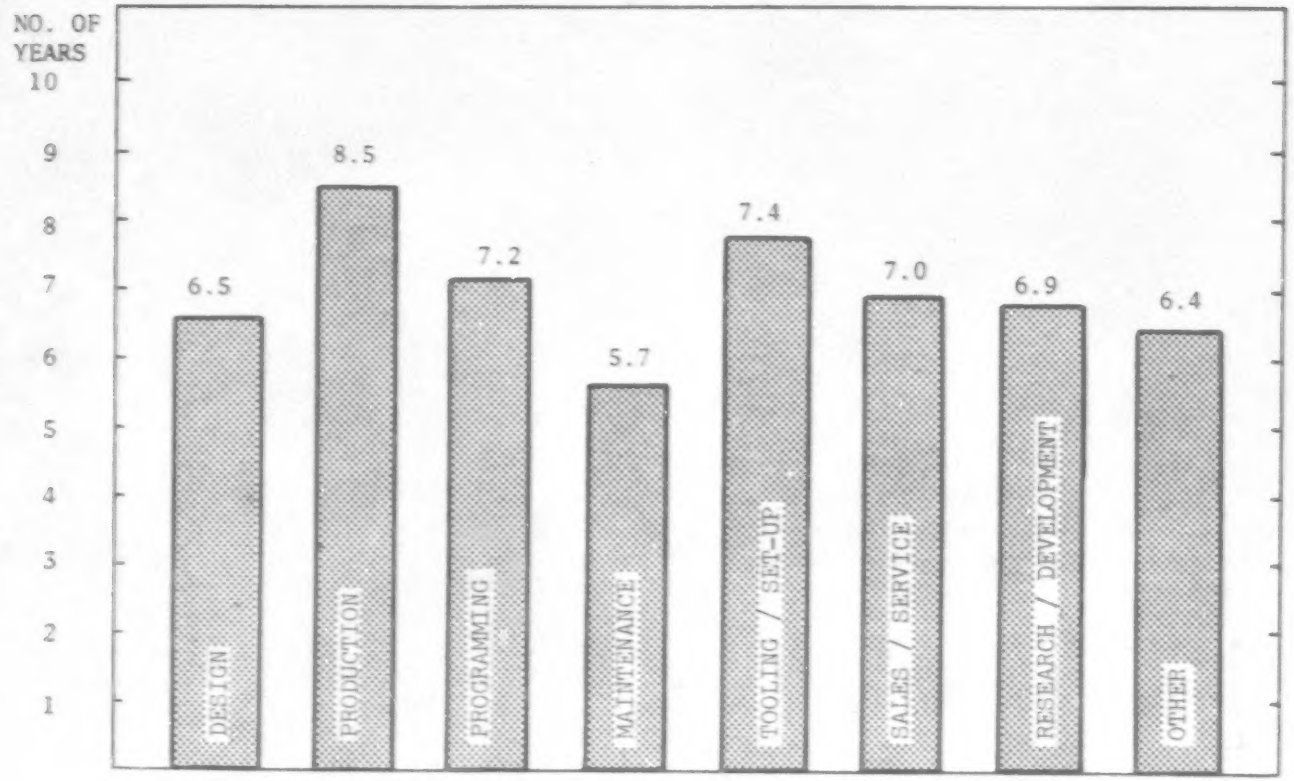


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TABLE 5

DISTRIBUTION OF FOUR CATEGORIES OF N/C PERSONNEL BY TYPE OF INDUSTRY
(AVERAGE NUMBER PER PLANT)

Type of Industry by Standard Industrial Classification Code	Number of Companies	N/C Machine Operators	N/C Maintenance Personnel	N/C Supervisors/ Coordinators	N/C Programmers
34. Fabricated Metal Products	(19)	20.1	4.3	2.3	5.5
35. Machinery except Electrical	(198)	20.7	4.6	2.1	3.8
36. Electrical & Electronic Equipment	(55)	15.0	4.5	2.0	4.6
37. Transportation Equip.	(62)	31.8	10.0	3.8	12.9
38. Instruments and Related Products	(14)	16.1	2.8	1.8	3.0
60. Administrative and Auxiliary	(52)	12.8	3.9	3.5	6.1
01. Other	(17)	15.4	2.2	1.4	3.4
Combined Average of	(417)	21.0	5.3	2.5	5.7
Total Number (10,897) and Percentage (100%)		6,883 (63%)	1,434 (13%)	674 (6%)	1,906 (18%)

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TABLE 6

DISTRIBUTION OF NEW N/C PERSONNEL FOR THE NEXT FIVE YEARS BY TYPE OF INDUSTRY
(AVERAGE ESTIMATED NUMBER PER PLANT)

Type of Industry by Standard Industrial Classification Code	Number of Companies	Manual Programmers	APT-Computer Programmers	Other Computer Programmers	N/C Machine Operators	N/C Maintenance Personnel	N/C Supervisors & Coordinators
34. Fabricated Metal Products	(19)	1	3.6	1.4	7.6	3.2	1.7
35. Machinery except Electrical	(198)	1.4	2.5	2.2	10.9	2.7	1.5
36. Electrical & Electronic Equip.	(55)	2.2	5.4	3.3	7.7	2.0	1.6
37. Transportation Equip.	(62)	2.5	7.3	3.5	15.9	6.0	2.0
38. Instruments and Related Products	(14)	1.33	1.5	2.2	2.5	1.0	1.3
60. Administrative and Auxiliary	(52)	1.0	2.9	3.4	4.5	1.8	1.5
01. Other	(17)	1.75	9.2	-	3.6	1.3	1.0
Combined Average of	(417)	1.6	4.6	2.6	10.6	3.0	1.6
Total Number (4,080) and Percentage (100%)		117 (2.5%)	530 (13%)	261 (6.5%)	2,520 (62%)	504 (12.5%)	150 (3.5%)

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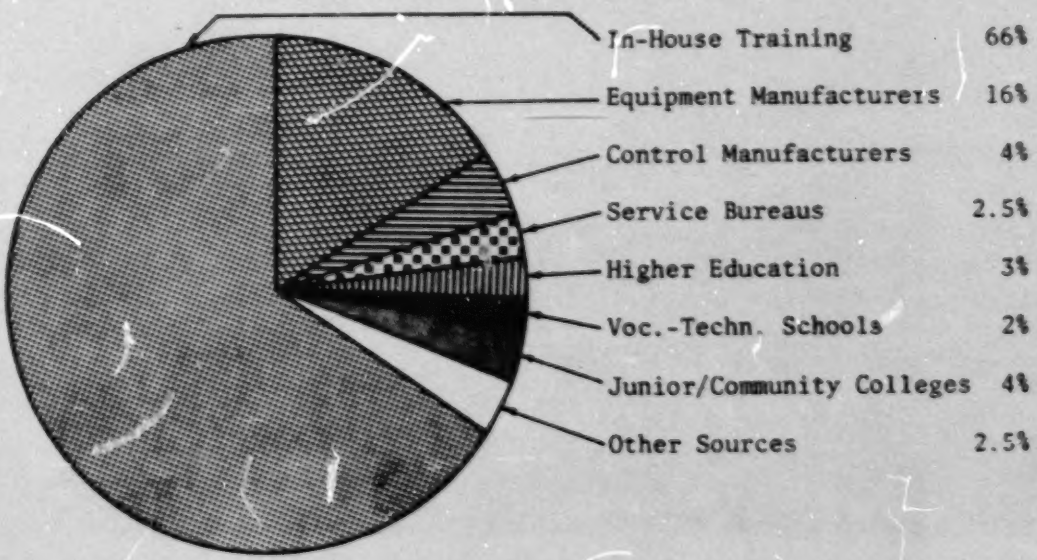
Manual programmers, APT computer programmers, and other computer programmers, adding up to an estimated total of 908 new personnel needed within the 417 industrial firms in the next five years.

Numerical control programmers represent the largest, projected increase (48 percent) over the next five years. The demand for new N/C machine operators was projected at more than 37 percent over current figures. A similar increase of 35 percent was estimated for N/C maintenance personnel, with the smallest increase, 22 percent over present numbers, in the group of N/C supervisors and coordinators.

Information concerning the different training sources of N/C personnel in industry was also collected. Figure 10 shows that of the various training sources listed, educational institutions were named in less than ten percent of all cases as the training source for their N/C employees.

FIGURE 10

AVERAGE PERCENTAGE OF
TRAINING SOURCES FOR N/C PERSONNEL



Current Status of N/C Machine Utilization

Tables 7 and 8 show the average number of numerical control machines, by type and controls, in use within the seven types of industry. The largest percentage of numerical control machines (30 percent) was the N/C lathe, 1,673 machines out of a total 5,517. The second largest category (25 percent) was N/C milling machines with 1,376 machines. The third group, N/C machining centers, represented 22 percent of the total, or 1,225. Finally, N/C drilling machines accounted for 21 percent or 1,150 machines. Table 8 specifies the average number of N/C control types for the different machine tools according to the type of industry. The most frequently used type of control was contour control with 55 percent of the total. Point-to-point control was second with 24 percent of the total. Mini-computers, with eleven percent of the total slightly outnumbered point-to-point combined with straight line controls.

Table 9 delineates the average number and type of numerical control machine tools projected to be purchased within the next five years by the seven types of industry. Of the total 829 machine tools, twenty percent increases are projected for both numerical control lathes and machining centers. An 8.5 percent increase in numerical control milling machines was also estimated.

TABLE 7

DISTRIBUTION OF MAJOR TYPES OF N/C MACHINES BY TYPE OF INDUSTRY
(AVERAGE NUMBER PER PLANT)

Type of Industry by Standard Industrial Classification Code	Number of Companies	N/C Drilling Machines	N/C Milling Machines	N/C Lathes	N/C Machining Centers	Other N/C Machines
34. Fabricated Metal Products	(19)	7.3	3.6	12.0	4.9	1.4
35. Machinery except Electrical	(198)	4.3	3.9	7.6	5.1	1.9
36. Electrical & Electronic Equipment	(55)	7.6	7.5	3.1	3.8	1.4
37. Transportation Equip.	(62)	4.9	13.7	3.7	5.5	2.2
38. Instruments and Related Products	(14)	4.8	2.7	3.7	3.2	1.0
60. Administrative and Auxiliary	(52)	4.5	4.2	9.1	5.7	2.2
01. Other	(17)	3.1	3.3	3.2	7.2	1.0
Combined Average of	(417)	5.2	6.7	6.4	5.0	1.5
Total Number and Percentage	(5,517) (100%)	1,150 (21%)	1,367 (25%)	1,673 (30%)	1,225 (22%)	102 (2%)

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TABLE 8

DISTRIBUTION OF TYPES OF N/C CONTROLS BY TYPE OF INDUSTRY
(AVERAGE NUMBER PER PLANT)

Type of Industry by Standard Industrial Classification Code	Number of Companies	Point-To-Point Controls	Point-To-Point & Straight Line	Contour Controls	Minicomputer
34. Fabricated Metal Products	(19)	5.7	5.2	11.86	1.7
35. Machinery except Electrical	(198)	4.2	4.6	9.5	3.5
36. Electrical & Electronic Equipment	(55)	10.6	6.5	6.1	9.7
37. Transportation Equip.	(62)	5.0	3.5	14.8	4.0
38. Instruments and Related Products	(14)	3.6	3.2	5.5	1.3
60. Administrative and Auxiliary	(52)	6.0	5.8	10.5	2.8
01. Other	(17)	7.3	3.3	2.28	1.5
Combined Average of	(417)	5.3	4.7	10.0	4.6
Total Number and Percentage	(5,395) (100%)	1,289 (24%)	546 (10%)	2,985 (55%)	575 (11%)

TABLE 9

DISTRIBUTION OF ESTIMATED NEW N/C MACHINE TOOL PURCHASES BY TYPE OF INDUSTRY
(AVERAGE NUMBER PER PLANT)

Type of Industry by Standard Industrial Classification Code	Number of Companies	N/C Drilling Machines	N/C Milling Machines	N/C Lathes	N/C Machine Centers	Other N/C Machines
34. Fabricated Metal Products	(19)	-	6.0	2.75	3.66	2.5
35. Machinery except Electrical	(198)	2.3	2.7	2.6	2.5	1.8
36. Electrical & Electronic Equipment	(55)	2.0	2.7	2.0	2.6	2.0
37. Transportation Equip.	(62)	1.8	2.2	3.5	4.1	2.2
38. Instruments and Related Products	(14)	1.0	2.0	1.0	1.0	1.0
60. Administrative and Auxiliary	(52)	2.0	2.0	2.0	1.25	1.0
01. Other	(17)	1.0	2.8	1.0	-	
Combined Average of	(417)	2.1	2.3	2.7	2.7	2.5
Total Number (829) and Percentage (100%)		73 (9%)	115 (14%)	331 (40%)	241 (29%)	69 (8%)

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Programming Practices for N/C

The following three figures illustrate a comparison of programming practices in industry and education, percentages of computer assisted programming in industry and the number of years of N/C utilization in the companies responding.

Figure 11 contrasts the percentages of the six main types of programming currently used in industry with those taught in education. This particular breakdown is of significance to education since it details the current emphasis on particular programming techniques or languages. The most apparent contrast between education and industry appears to be between manual versus computer programming percentages.

Figure 12 provides data on the current percentages of computer utilization for programming. Percentages are based on the total number of companies answering Part I, assuming that the 109 (26 percent) industries not responding to this particular question do not use computers for programming purposes. Thirty-eight percent indicated that they utilize time sharing services, 27 percent operate their own in-house computer, and nine percent utilize both services.

Figure 13 provides information on the average number of years that companies have used numerical control machine tools. Based on these responses, 75 companies (22 percent) began using N/C within the last five years. The majority, 142 companies (41 percent) have been using N/C for 6-10 years, 80 companies (24 percent) for 11-15 years, 40 companies (21 percent) for 16-20 years, and 3 companies (one percent) for 21 or 22 years.

FIGURE 11

PERCENTAGE USE OF SIX MAIN PROGRAMMING TECHNIQUES
(COMPARISON OF INDUSTRY AND EDUCATION)

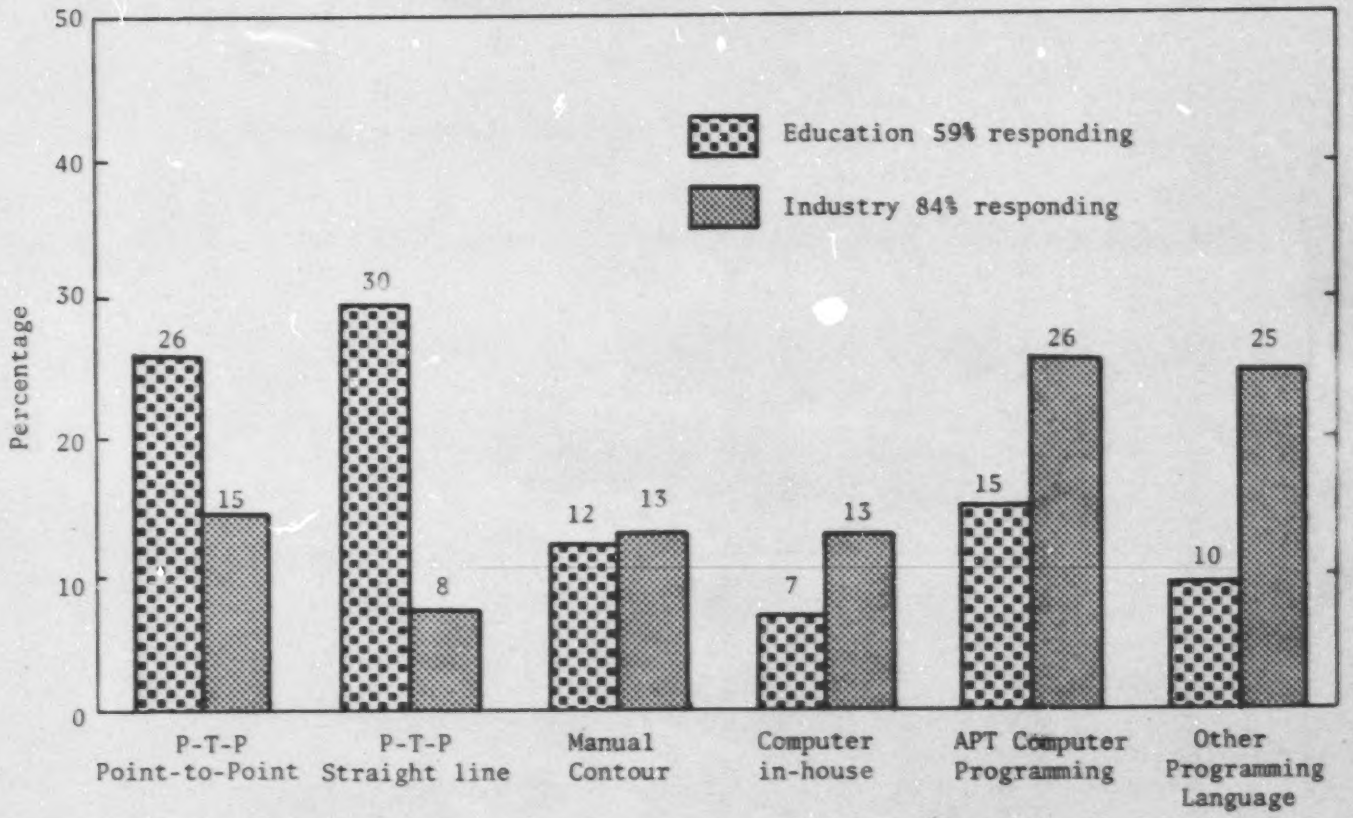


FIGURE 12
USE OF TIME-SHARE OR IN-HOUSE COMPUTER
(308 (74%) COMPANIES RESPONDING)

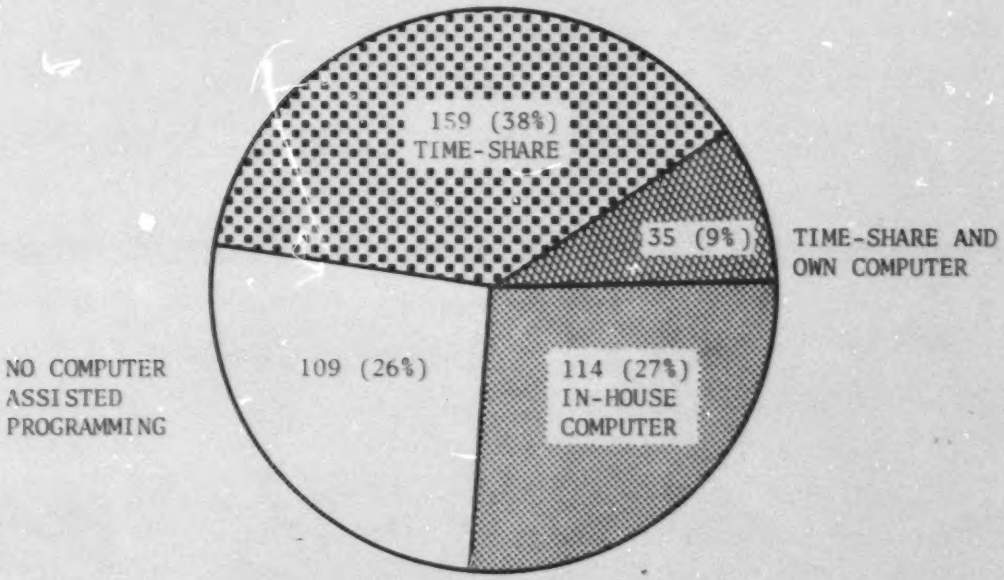
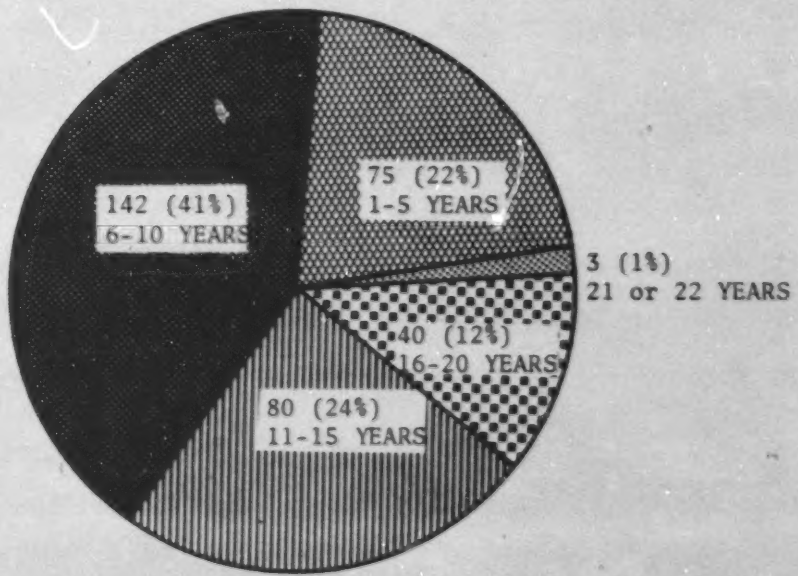


FIGURE 13
AVERAGE NUMBER OF YEARS COMPANIES HAVE USED N/C MACHINES
(340 (82%) COMPANIES RESPONDING)



The Status of NC/CAM Instruction in Industrial Education and Technology Programs

Upon analyzing Part I of the survey responses from the educational group, information was compiled which revealed the general characteristics of current educational programs in numerical control technology in industrial teacher education departments, technology departments, and junior colleges. The following data presentations provide an overview and summary of some of the more relevant aspects of the present educational programs in this field. The following data was statistically analyzed utilizing the Veldman (1967) Distat program which provided detailed information on all responses from the questionnaire, such as means, standard deviation, frequency distribution, and the respective number of responses to each item. The following tables and figures illustrate the individual responses by grouping the data into three main areas: (1) faculty and student representations, (2) availability of N/C equipment, and (3) programming and computer utilization.

Faculty and Student Distribution by Institution

Table 10 presents a distribution of the average number of faculty per department as well as the average number of students enrolled by type of program: four-year industrial teacher education, four-year engineering technology, and two-year occupational-technical programs.

TABLE 10

DISTRIBUTION OF FACULTY AND STUDENTS BY TYPE OF INSTITUTION
(AVERAGE NUMBER PER DEPARTMENT)

Type of Institution (Responses)	Average Number of Faculty			Average Number of Students				
	Full time	Part time	Teaching N/C	Major	Non-Major	Per Year	Per N/C course	Per N/C Lab Section
Four-Year Industrial Teacher Educ. 60 (94%)	12.6	5.0	1.5	297.7	146.0	32.7	18.7	16.1
Fou-Year Engineering Technology 18 (100%)	10.2	5.7	1.8	141.8	110.3	66.0	18.8	16.5
Two-Year Occupational-Technical 24 (87%)	3.1	3.0	1.7	73.0	64.5	44.0	17.7	15.9
Combined Average	10.0	4.7	1.6	206.0	121.0	40.4	18.5	16.1

These averages illustrate the number of full and part-time faculty members, and the number of faculty members teaching numerical control courses. Although the combined average was ten full-time faculty per department, individual schools ranged from one to 45 faculty members per department. The number of faculty members involved in N/C technology ranged from one to eight individuals per department. On the other hand, the average number of students taking N/C courses per year was 40.4, with a range from eleven to 200. The number of students per N/C course averaged 18.5 and ranged from five as a minimum to 50 maximum. The number of students per laboratory section ranged from one to 36, with an average of 16.1 in each section.

Table 11 indicates the background of the faculty members responding to the questionnaire from the three types of programs with respect to their competency in numerical control. These figures indicate that the majority of the educators answering acquired their competency in numerical control through actual teaching experience or N/C work experience. On the average, teachers acquired their knowledge in N/C through 5.5 years of teaching experience or 3.9 years of work experience, compared with 2.2 years average through formal N/C education (Overall average is not cumulative). Additional information not illustrated in the table concerns the main teaching areas of the respondents. The average number of years was: Ten years in industrial education, 9.6 years in engineering technology, eight years in vocational education,

TABLE 11

DISTRIBUTION OF FACULTY RESPONDENT BACKGROUND IN N/C
(AVERAGE NUMBER OF YEARS PER FACULTY)

Type of Institution (Responses to Question)	Competency in N/C Aquired in Years					
	Formal Education in N/C	Correspondence Courses in N/C	N/C Self-Taught	N/C Teaching Experience	N/C Working Experience	Combined* Total
Four-Year Industrial Teacher Educ. 52 (81%)	1.5	1	4.3	5.9	4.5	6.7
Four-Year Engineering Technology 13 (72%)	1.6	0	2.8	4.9	3.1	10.0
Two-Year Occupational Technical 23 (85%)	4.4	0	4.2	4.6	3.6	7.9
Combined Average	2.2	1	4.0	5.5	3.9	7.7

*NOTE: Because of multiple answers to this question the combined total number of years of N/C background is not arithmetically cumulative.

and 6.5 years in technical education and industrial technology respectively. The combined average number of years in teaching was 13.8 years (Combined average is not cumulative).

Table 12 provides the distribution of survey questionnaires to three main groups. This data shows that the overall percentage of returns for Part I (54 percent) was surpassed by industrial teacher education institutions, showing 62 percent returns, and by occupational-technical programs with 61 percent returns. Engineering technology institutions returned 32 percent. This table also shows the number of existing N/C programs in those institutions answering the questionnaire. The table also lists the number of institutions with future plans or no plans for offering N/C programs. Table 12 also indicates that eleven respondents partially filled out the questionnaire but stated that their schools did have no plans to begin an N/C program in the immediate future.

The data also indicates that there are 97 individual N/C courses presently offered in the 58 institutions answering this particular question ranging in number from one course, in 33 of the institutions answering this question, to seven courses in one particular case. With respect to the level of courses in N/C, ten percent are offered at the freshman level or during the first year of junior college, 26 percent at the sophomore or during the second year of junior college, 34 percent at the junior level, and 30 percent at the senior level.

TABLE 12

PRESENT AND PROJECTED N/C PROGRAMS BY TYPE OF EDUCATIONAL INSTITUTION
(NUMBER AND PERCENTAGE)

Educational Institutions	Survey Mailing	Total Responses		Present N/C Programs		Future Plans		No Plans	
		N	%	N	%	N	%	N	%
Four-Year Industrial Teacher Education	104	64	62%	46	72%	14	22%	4	6%
Four-Year Engineering Technology	56	18	32%	11	61%	3	17%	4	22%
Two-Year Occupational-Technical	44	27	61%	24	89%	--	--	3	11%
Totals	202	109	54%	81	74%	17	16%	11	10%

Distribution of N/C Versus Non-N/C Machine Tools

Table 13 provides a summary of the average distribution of N/C and non-N/C machine tools while Table 14 indicates the distribution of the number and type of N/C machine tools which educational institutions estimate purchasing in the near future.

Table 13 illustrates the breakdown, by type of program, of the four main types of numerical control machine tools currently utilized in educational programs. The largest number was N/C milling machines leading the other three categories with 68 machines or 65 percent of all machines listed. Next followed drilling machines with 22 (21 percent). Surprisingly, the number of N/C machining centers was nine (8.5 percent), surpassing the number of N/C lathes, six (5.5 percent).

In contrast, in the distribution of conventional machine tools three main groups appeared as follows: the largest group was lathes with 753 (56 percent), followed by milling machines with 332 (25 percent), and drilling machines with 252 (nineteen percent). With respect to the number of schools utilizing N/C machine tools: Fifty-nine utilized N/C milling machines, 21 schools used N/C drilling machines, and six schools had one N/C lathe each compared to nine schools with one N/C machining center each. Thus, the overall total was 105 N/C machines versus 1,341 conventional non-N/C machine tools resulting in a proportion of approximately one N/C to thirteen non-N/C machine tools.

TABLE 13

DISTRIBUTION OF N/C VERSUS NON-N/C MACHINE TOOLS BY TYPE OF INSTITUTION
(NUMBER OF MACHINES BY MAJOR TYPES)

Type of Institution (Responses to Question)	Number of Machine Tools					
	Total N/C Machine Tools 105				Total Non-N/C Machi	
	Drilling Machines	Milling Machines	Lathes	Machining Centers	Drilling Machines	Milli Machi
Four-Year Industrial Teacher Educ. 50 (81%)	11	39	4	4	119	149
Four-Year Engineering Technology 14 (78%)	5	13	2	2	44	69
Two-Year Occupational-Technical 26 (96%)	6	16	-	3	87	114
Subtotals and Percentages	22 (21%)	68 (65%)	6 (5.5%)	9 (8.5%)	252 (19%)	332 (25%

TABLE 13

DISTRIBUTION OF N/C VERSUS NON-N/C MACHINE TOOLS BY TYPE OF INSTITUTION
(NUMBER OF MACHINES BY MAJOR TYPES)

	Number of Machine Tools						
	Total N/C Machine Tools 105				Total Non-N/C Machine Tools 1,[illegible]		
	Drilling Machines	Milling Machines	Lathes	Machining Centers	Drilling Machines	Milling Machines	Lathes
uc.	11	39	4	4	119	149	411
g	5	13	2	2	44	69	118
al-	6	16	-	3	87	114	224
and s	22 (21%)	68 (65%)	6 (5.5%)	9 (8.5%)	252 (19%)	332 (25%)	753 (56%)

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Figure 14 compares the proportion of non-N/C machines to N/C machines for each of the three main groups of machine tools. The proportion of non-N/C to N/C drills is twelve to one, for milling machines approximately five non-N/C to one N/C machine. The proportion for lathes is 125 conventional lathes to every one numerical control lathe.

A further comparison of the type of N/C controls utilized by schools shows that 50 percent of the controls are point-to-point, 24 percent are contour controls. Six schools report utilizing minicomputers for N/C instruction. This contrasts with the large proportion of contour control machines (55 percent) and minicomputers (eleven percent) used by the industries providing information to this question. As far as the number of axis are concerned: 49 schools reported having 58, two-axis machines, 35 schools reported using 41, three-axis machines, and one school employed one, five-axis machine.

Table 14 illustrates the breakdown, by type of institution, of the estimated number and type of new numerical control machine tools to be purchased in the near future. This table provides insight into the overall planning estimates for new machine tool acquisitions. According to the responses, 36 or 70 percent of the total machine tool purchases were planned by industrial arts departments, eight machines (sixteen percent) by junior colleges, and seven (fourteen percent) by

FIGURE 14

PROPORTION AND NUMBER OF N/C VERSUS NON-N/C MACHINE TOOLS FOR FOUR MAJOR TYPES OF MACHINES
(TOTAL NUMBER AND PERCENTAGE FOR ALL EDUCATIONAL RESPONDENTS)

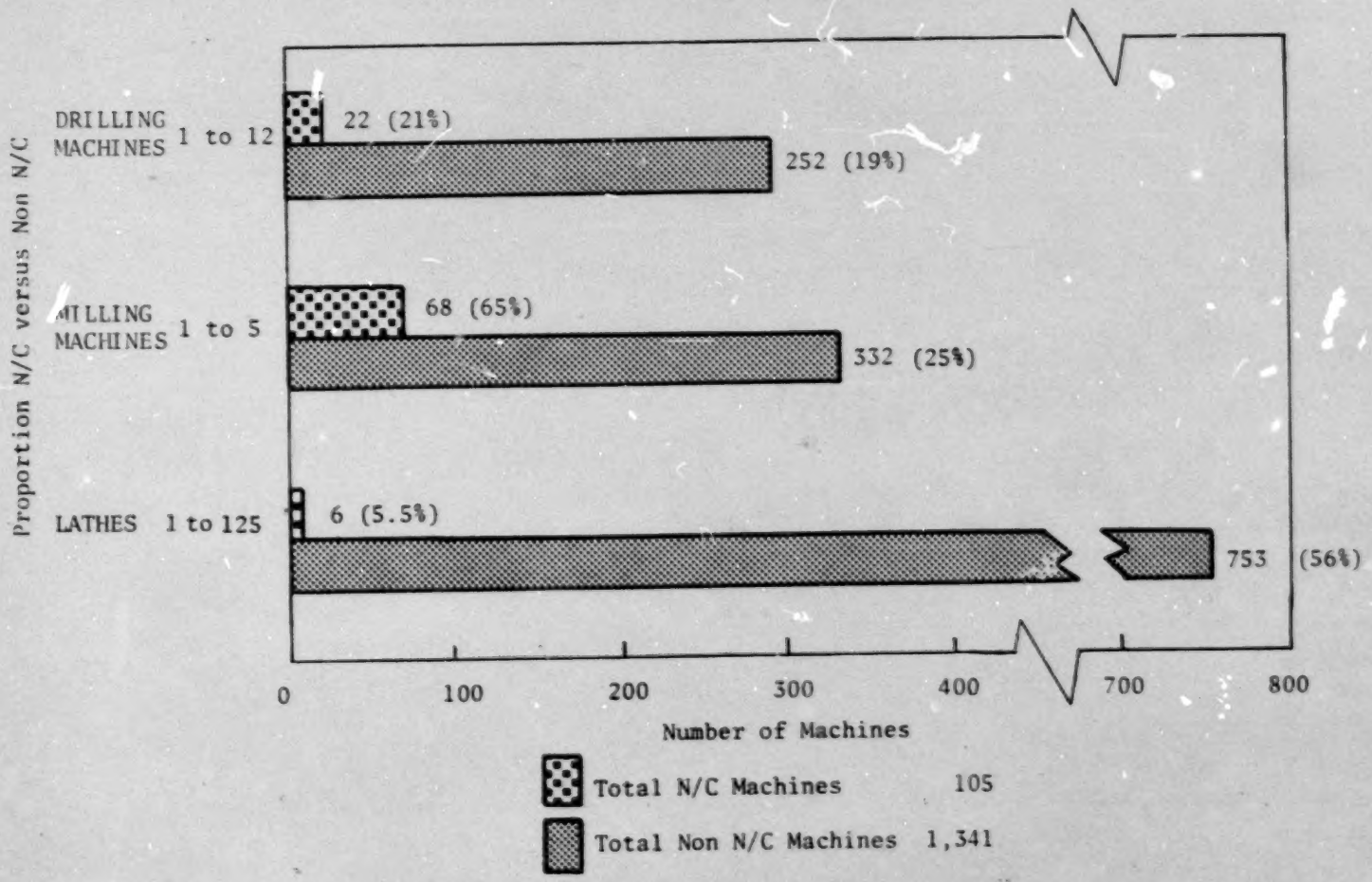


TABLE 14

DISTRIBUTION OF ESTIMATED NEW N/C MACHINE TOOL PURCHASES BY TYPE OF INSTITUTI
(NUMBER OF MACHINES BY MAJOR TYPES)

Type of Institution (Responses to Question)	Type of N/C Machine				
	N/C Drilling Machines	N/C Milling Machines	N/C Lathes	N/C Machining Centers	Others
Four-Year Industrial Teacher Educ. 25 (39%)	1	14	14	5	2
Four-Year Engineering Technology 4 (22%)	0	3	2	1	1
Two-Year Occupational-Technical 8 (30%)	1	3	4	-	-
Total Percentage	2 (4%)	20 (39%)	20 (39%)	6 (12%)	3 (6%)

TABLE 14

ION OF ESTIMATED NEW N/C MACHINE TOOL PURCHASES BY TYPE OF INSTITUTION
(NUMBER OF MACHINES BY MAJOR TYPES)

	Type of N/C Machine				
rilling ines	N/C Milling Machines	N/C Lathes	N/C Machining Centers	Others	Total
1	14	14	5	2	36(70%)
0	3	2	1	1	7(14%)
	3	4	-	-	8(16%)
%)	20 (39%)	20 (39%)	6 (12%)	3 (6%)	51 (100%)

engineering technology departments. The total number of 51 machines is distributed among the four major machine types as follows: Twenty (39 percent) for numerical control milling machines and an equal number for numerical control lathes, six (twelve percent) for N/C machine centers, two (four percent) for N/C drills, and six percent for other non-specified N/C machine tools. These figures are estimates and do not represent any committed purchase orders for particular acquisitions.

N/C Programming in Education

Figure 15 compares the industrial and educational responses to the item pertaining to the approximate percentage of time each devoted to the six major categories of programming techniques: (1) manual point-to-point, (2) manual point-to-point and straight line, (3) manual contour, (4) computer in-house language, (5) APT-programming, (6) other languages. Though the amount of time varied among industries and schools, an overall estimate was calculated for 59 percent of the 81 educational institutions and 84 percent of the industries responding to this question.

Figure 15 shows that individual percentage estimates for these six different techniques used in education contrast with the corresponding responses from the industrial group. The outstanding difference occurs in the category of manual programming, specifically manual point-to-point and point-to-point combined with straight line programming.

FIGURE 15

N/C PROGRAMMING IN EDUCATION COMPARED WITH CURRENT PRACTICES IN INDUSTRY
(ADJUSTED AVERAGE PERCENTAGE)

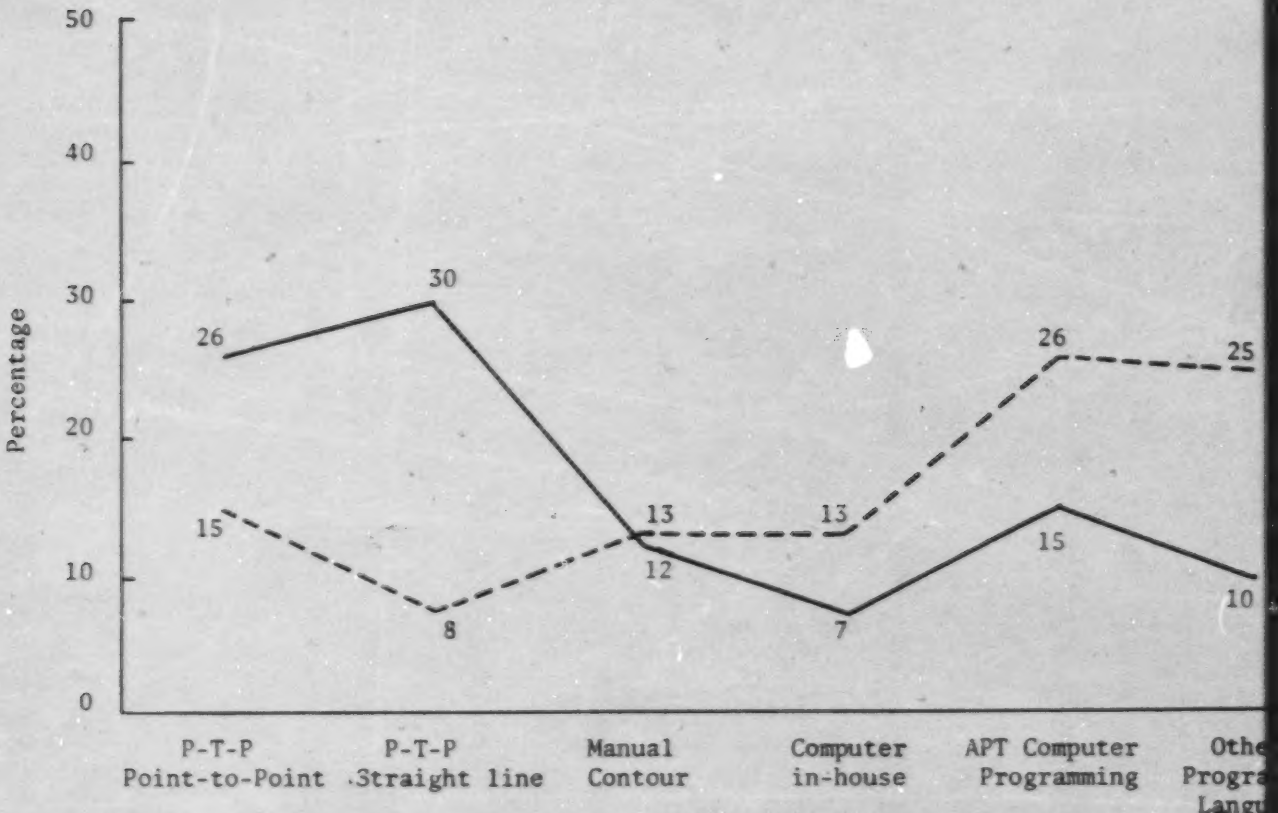
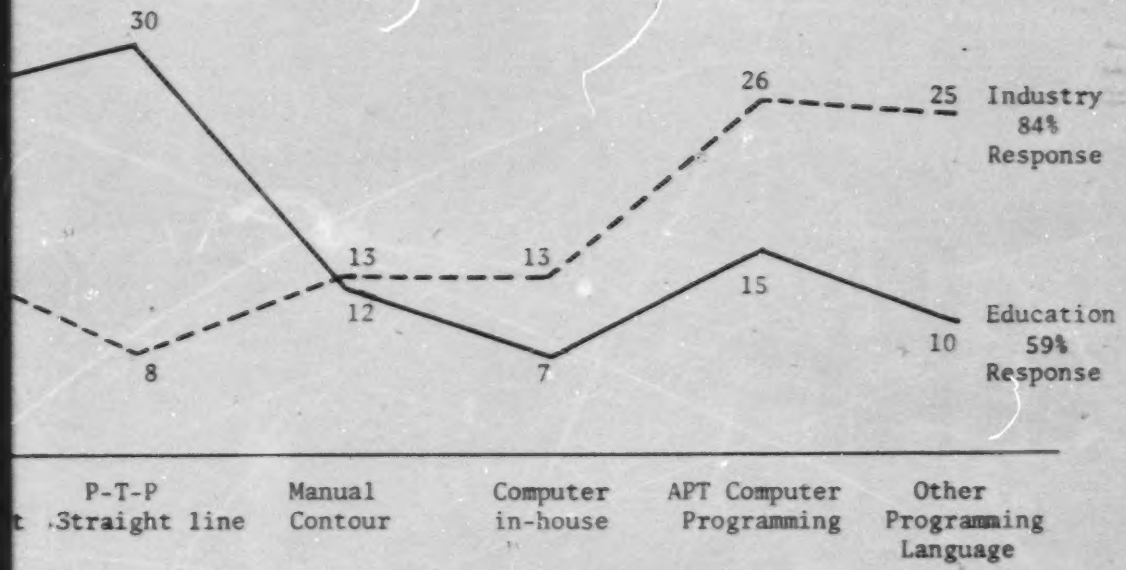


FIGURE 15

MING IN EDUCATION COMPARED WITH CURRENT PRACTICES IN INDUSTRY
(ADJUSTED AVERAGE PERCENTAGE)



Approximately 56 percent of the time spent on part programming instruction in education is dedicated to these two techniques while industry uses it only 23 percent of the time. Another difference between educational and industrial programming techniques exists in the category of computer programming. In industry, 26 percent of all programming uses the APT language (Automatic Programmed Tools), while only fifteen percent of the 57 schools responding provide instruction in this language. An almost equal percentage of time, specifically 25 percent of programming in industry is performed in non-APT languages with a considerable portion of this programming being done in Compact II, an interactive timeshare based N/C programming language. In contrast, only ten percent of the programming in education is non-APT with only two schools reporting instruction in Compact II.

Figure 16 provides information concerning the utilization of in-house computers or timeshare services for computer assisted N/C programming in education. Of the 81 schools presently offering N/C courses, only 37 (46 percent) responded to this particular question. This figure shows that 44 (54 percent) of the schools having N/C programs are not in a position to take advantage of the computer for N/C programming applications. Among the remaining 37 (46 percent) using the computer for N/C programming, 28 (35 percent) departments utilized a university based computer, six (seven percent) others used timeshare services and three (four percent) institutions applied both

FIGURE 16

USE OF TIME-SHARE OR IN-HOUSE COMPUTER
(BASED ON 81 (74%) N/C PROGRAMS IDENTIFIED)

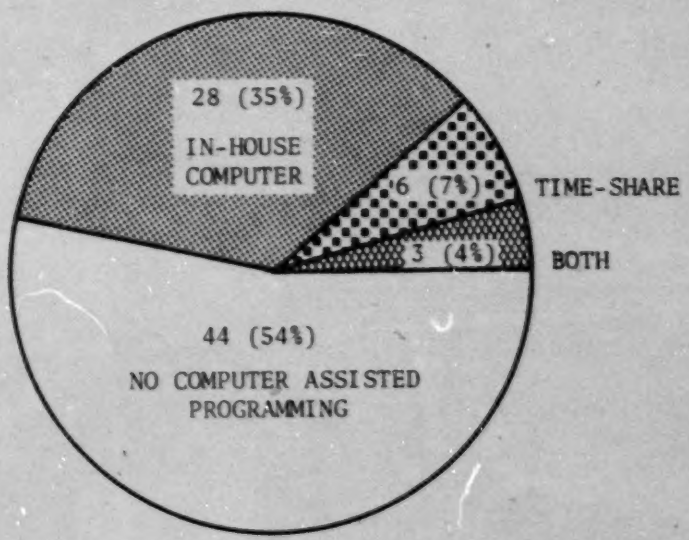
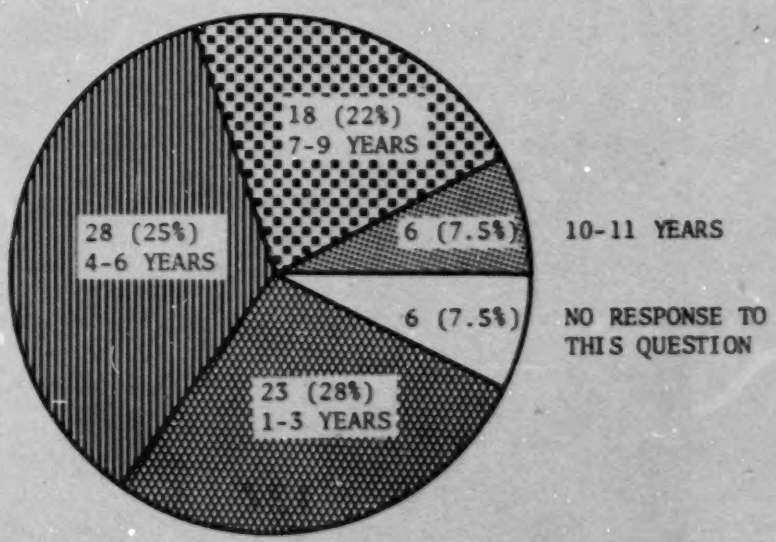


FIGURE 17

AVERAGE NUMBER OF YEARS DEPARTMENTS HAVE OFFERED N/C INSTRUCTION
(BASED ON 75 (69%) INSTITUTIONS RESPONDING)



systems. This contrasts sharply with the industrial response where 73 percent of all companies responding indicated the use of some form of computer assisted N/C part programming.

Figure 17 illustrates the average number of years that departments who offer N/C courses have had their program. The data in this graph indicates that although the technology was developed over twenty years ago, only six schools (7.5 percent of the respondents) offered instruction in numerical control for ten to eleven years. Eighteen (22 percent of the 81 schools) have taught N/C for seven to nine years, while 28 (35 percent) had N/C courses for four to six years, and 23 (28 percent) offered N/C for one to three years. Six schools having N/C courses did not specify how old the programs were. The importance of these figures lies in the fact that well over 60 percent of the schools presently offering N/C instruction began the programs less than six years ago. Though this indicates that education entered the field somewhat late, the data shows an increased awareness among educators of the growing importance of this new technology for their students. Though 26 percent of those answering Part I of the questionnaire have not yet begun an N/C program, their desire to participate in the study demonstrates a growing trend to incorporate numerical control instruction into technical education programs.

In conclusion, the responses of educators to Part I of the survey instrument provided needed information concerning the status of numerical control technology instruction in industrial education and tech-

nology programs. The data also gave valuable insights into the current trends in N/C education in post-secondary institutions in the United States.

Comparison of the Industrial and Educational Listings of Requisite Tasks and Topics in NC/CAM

Part II of the survey instrument consisted of the NC/CAM Training Topic Inventory which listed a total of 98 items in five main areas of numerical control technology and computer aided manufacturing. These areas were: (1) Basic N/C Concepts, (2) Manual Programming, (3) Computer Programming, (4) Management Aspects of N/C, and (5) Advanced Technologies. In order to obtain relevant data for a comparative analysis between the two main survey groups, both education and industry participants received the same form of Part II of the instrument. The 492 individuals in industry and 84 respondents in education rated the relative value of importance of each item on a 1-5 Likert scale (5-great, 4-substantial, 3-moderate, 2-limited, 1-none). Since both educational and industrial respondents received the same NC/CAM Training Topic Inventory Part II could be compared on an item by item basis within each of the five topic areas.

Item Analysis and Response Frequencies to the NC/CAM Training Topic Inventory

For a detailed statistical analysis, Veldman's program (1967, pp. 170-181) TESTAT was utilized to calculate the means, standard deviation, item to total correlation (RT), item to area correlation

(RS), as well as percentage choice distribution for every item and area subgroup. The program also determined the degree of reliability of the survey instruments by computing the alpha coefficient of internal consistency for each of the five areas of the inventory. Table 15 presents a list of the area means, standard deviations, and the reliability coefficients for each area. The complete questionnaire had a combined reliability coefficient of 0.9565 and 0.9848 for industrial and educational participants respectively. Since this specific statistical program did not compute the response frequencies for each item, however, another routine had to be selected which would calculate this additional information valuable for a comparison of group responses to the instrument.

TABLE 15

RELIABILITY OF THE NC/CAM TRAINING TOPIC INVENTORY

Main Areas	Mean		Standard Deviation		Reliability Coefficient	
	Industry	Education	Industry	Education	Industry	Education
Basic N/C Concepts	3.4543	3.5727	0.9641	1.0211	0.8315	0.9052
Manual N/C Programming	3.6927	3.5257	0.9831	1.1518	0.9219	0.9321
Computer N/C Programming	3.2612	2.7142	1.1212	1.2461	0.9106	0.9804
Management Aspects of N/C	3.6532	2.8333	0.9543	1.1850	0.9107	0.9779
Advanced Technologies	3.1275	2.5386	1.0498	1.2000	0.9268	0.9816
Totals	3.4421	3.0190	1.0145	1.1662	0.9565	0.9848

Veldman's program (1967, pp. 319-325) TSCALE provided an item-by-item frequency distribution of responses which was used to calculate total frequencies per importance rating and to compare percentages on an area-by-area basis. This comparison of industry and education responses by area for the complete topic inventory is summarized in Tables 16-21. The two groups are contrasted according to the number of different importance ratings given and the corresponding percentages. Although the rating scale was limited to values from one to five, corresponding to ratings of no importance to great importance, the number of no responses was also included, thus accounting for the missing data of incomplete questionnaires. The reported frequency and percentages are based on 492 responses for the industrial group and 84 responses for the educational group respectively.

Response Frequencies to Items 1-98

Table 16 shows the total frequency distribution for the industrial and educational responses to all 98 items and the corresponding percentage distribution for each importance point on the rating scale. Among industrial responses an average of 30 percent of all items received a ranking of four (substantial importance) and 21 percent were ranked five (great importance). In contrast, educational responses rated 23 percent of all items with four points and seventeen percent with five points on the importance scale. The data also indicates that 79

TABLE 16
NC/CAM TRAINING TOPIC INVENTORY (1-98)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	9,511	21	21	5	1,256	17	17
4	13,558	30	51	4	1,690	23	40
3	12,638	28	79	3	1,668	23	63
2	7,228	16	95	2	1,222	17	80
1	2,155	5	100	1	1,410	20	100
Total	45,090	100%	100%	Total	7,246	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 3,126 (7%) No Response Items = 986 (14%)

99

percent of all items of moderate or higher importance, the education group considered only 63 percent of all items of similar importance. The industry group returned seven percent of all items imcomplete (missing data) compared to fourteen percent unanswered by the education group. Of 502 total industrial respondents, ten (two percent) returned Part II of the instrument unanswered. Of the 125 total educational returns, sixteen (thirteen percent) were not answered for both parts of the questionnaire while an additional 25 (28 percent) educators did not respond to Part II of the instrument. Understandably, however, this high percentage of incomplete questionnaires from education can be accounted for by responses from institutions with no current N/C-program. Nevertheless, 109 respondents did provide details concerning the present status of their respective programs by answering items in Part I of the instrument. Thus, the number of completed responses to Part I helped to increase the accuracy of the analysis of the status and current trends in N/C-instructional programs in industrial education and technology.

Comparison of Response Frequencies by Area

By further analyzing the group responses according to individual areas of the NC/CAM Training Topic Inventory, the specific differences in opinions and attitudes between the two groups with respect to elements of priority for N/C instructional programs became more apparent. A

comparison on an area-by-area basis revealed variations in the two group's perceptions of what the priority areas are for curriculum development in N/C technology. Table 17 presents the distribution of responses for Area I, Basic N/C Concepts. It shows 78 percent of all items in this area rated of moderate to great importance by industry in comparison to 80 percent in the educator's group. This was the only area which received a higher rating by educators as compared to industrialists. Table 18 analyzed results for Area II, Manual Programming. Industrial responses rated 86 percent of all items of moderate or higher importance compared to 78 percent among educational responses. A more pronounced difference occurred in Area III, Computer Programming. As indicated in Table 19, 73 percent of all items received a moderate or higher importance value from the industrial group as compared to 52 percent from the educational group.

Table 20 contrasts Area IV, Management Aspects of N/C, for the two survey populations resulting in a difference in value attached to the individual items. The industrial group rated 87 percent of the items at three or higher importance as compared to 60 percent by the educational group.

Finally, Table 21 presents the response frequencies for Area V, Advanced Technologies. As anticipated, items in this area received the lowest importance rating with respect to their value for educational programs. Whereas the industrial group still considered at

TABLE 17
AREA I BASIC N/C-CONCEPTS (ITEMS 1-18)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	1,831	21	21	5	383	25	35
4	2,438	28	49	4	447	30	55
3	2,494	29	78	3	372	25	80
2	1,652	19	97	2	233	16	86
1	216	3	100	1	57	4	100
Total	8,631	100%	100%	Total	1,492	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 405 (5%)

TABLE 18
AREA II MANUAL PROGRAMMING (ITEMS 19-36)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	2,124	25	25	5	413	28	28
4	2,976	35	60	4	404	28	56
3	2,240	26	86	3	324	22	78
2	909	11	97	2	203	14	92
1	184	3	100	1	116	8	100
Total	8,451	100%	100%	Total	1,460	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 405 (5%) No Response = 52 (4%)

TABLE 19
AREA III COMPUTER ASSISTED PROGRAMMING (ITEMS 37-60)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	2,047	19	19	5	219	13	13
4	2,836	26	45	4	331	19	32
3	3,024	28	73	3	335	20	52
2	1,889	18	91	2	267	16	68
1	1,001	9	100	1	539	32	100
Total	10,797	100%	100%	Total	1,691	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 1011 (9%) No Response Items = 325 (19%)

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TABLE 20
AREA IV MANAGEMENT ASPECTS (ITEMS 61-82)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	2,464	24	24	5	173	11	11
4	3,655	36	60	4	353	22	33
3	2,710	27	87	3	433	27	60
2	1,143	11	98	2	301	18	78
1	253	2	100	1	351	22	100
Total	10,225	100%	100%	Total	1,611	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 599 (6%) No Response Items = 237 (15%)

TABLE 21
AREA V ADVANCED TECHNOLOGIES (ITEMS 83-98)
DISTRIBUTION AND COMPARISON OF INDUSTRIAL AND EDUCATIONAL RESPONSES

Industrial Responses (492)				Educational Responses (84)			
Importance Rating	Total Frequency	Percentage	Cumulative Percentage	Importance Rating	Total Frequency	Percentage	Cumulative Percentage
5	1,027	15	15	5	68	7	7
4	1,653	24	39	4	155	15	22
3	2,170	31	70	3	204	21	43
2	635	23	93	2	218	22	65
1	501	7	100	1	347	35	100
Total	6,986	100%	100%	Total	992	100%	100%

Note: Based on a 1-5 Likert Scale Rating from No Importance to Great Importance
No Response Items = 886 (12%) No Response Items = 352 (36%)

least 70 percent of all items of moderate to great importance, only 43 percent received this rating from the educational group.

Areas IV, Management Aspects, and V, Advanced Technologies, also showed the largest disagreement between the two survey groups, with 27 percent difference in rating for all items of moderate to substantial importance, which indicated the diversity of views regarding the relevance of these topics for educational programs in NC/CAM. In addition, not all items in Area V, Advanced Technologies, were rated by educational respondents. These results can most likely be attributed to the greatly varying characteristics of the educational institutions and respondents, as well as the obviously different purposes and goals of these programs in industrial education, engineering technology, and occupational-technical programs. However, further analysis and comparison between the two main survey groups is necessary in order to explain differences and identify those items which are essential and relevant for educational programs in N/C Technology.

Comparison of Industrial and Educational Mean Responses

After comparing the response frequencies and percentages of importance ratings for the two survey groups for each of the five main areas of the NC/CAM Training Topic Inventory, a detailed comparison of group mean responses was carried out. This facilitated an item by item comparison as well as an overall contrast of combined area ratings for the respective groups.

Industrial and Educational Means by Item

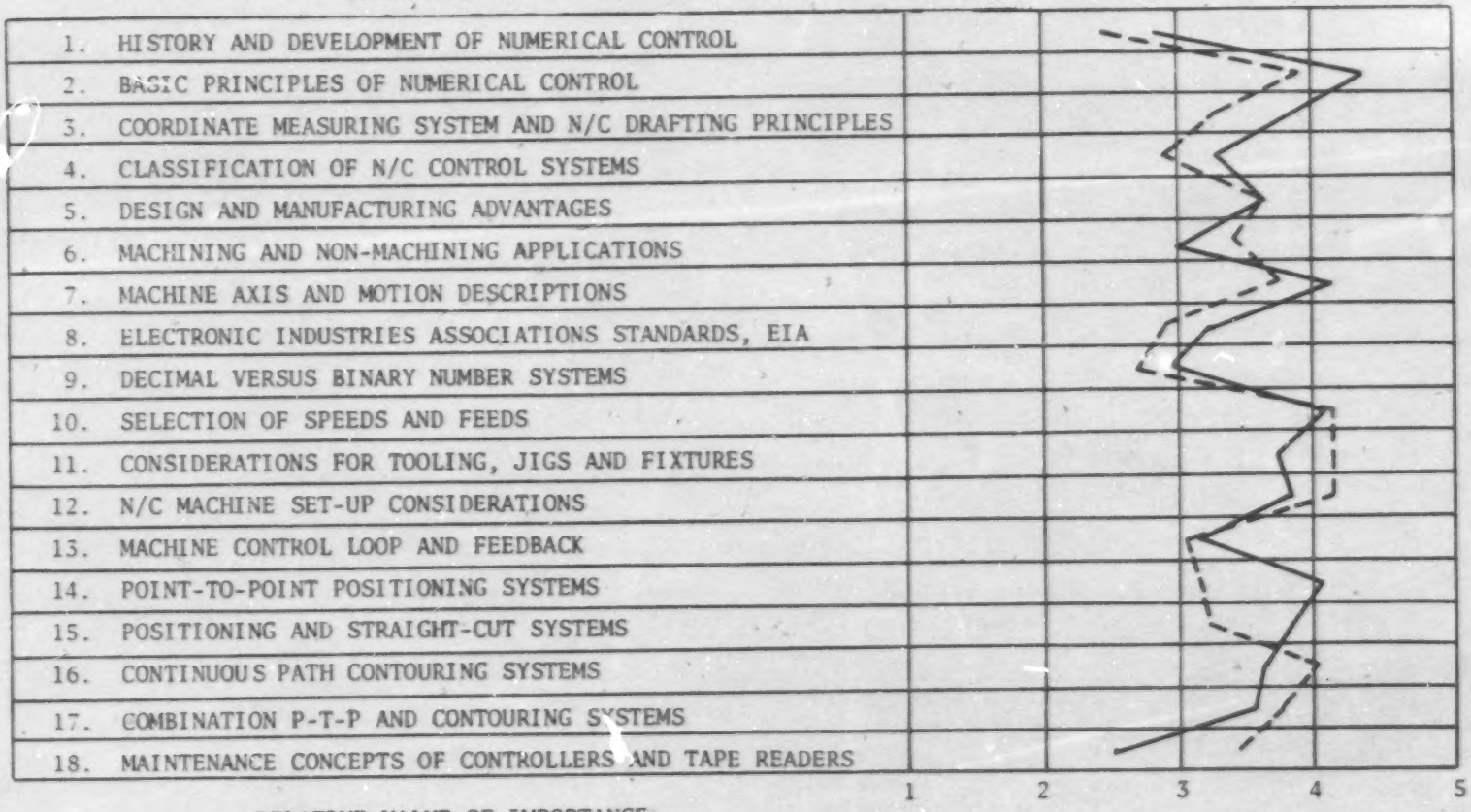
Figures 18 through 22 illustrate graphically the individual group mean responses on an item by item basis. Based on the five point rating scale, these means are symbolically represented providing a visual contrast of the mean differences.

As can be seen in Figure 18, a certain degree of similarity in the responses of the two groups exists despite the different importance ratings given to individual items. Thus, the overall trend, though different in absolute means, reveals similar views regarding the training topics listed in Area I, Basic N/C Concepts. The majority of items in this area do not differ for more than 0.4 points on the importance scale, however, the higher ratings alternate between groups several times. The largest disagreement, appeared to exist for the value of items 14 and 15 Point-To-Point Positioning Systems and Positioning and Straight-Cut Systems with 0.9 and 0.6 points difference of opinion respectively. In both cases, the industry respondents accounted for the lower ratings. In comparing the area of Basic N/C Concepts with the other areas, it can be seen that this was the only area of the NC/CAM Training Topic Inventory which received an overall higher rating value by education respondents. Generally, lower ratings were given by educators to the other four areas.

Figure 19 illustrates the mean responses for items concerned with Manual Programming. A more pronounced difference of opinion with

FIGURE 18

NC / CAM TRAINING TOPIC INVENTORY: AREA 1 BASIC N/C CONCEPTS
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES


1. HISTORY AND DEVELOPMENT OF NUMERICAL CONTROL
2. BASIC PRINCIPLES OF NUMERICAL CONTROL
3. COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES
4. CLASSIFICATION OF N/C CONTROL SYSTEMS
5. DESIGN AND MANUFACTURING ADVANTAGES
6. MACHINING AND NON-MACHINING APPLICATIONS
7. MACHINE AXIS AND MOTION DESCRIPTIONS
8. ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS, EIA
9. DECIMAL VERSUS BINARY NUMBER SYSTEMS
10. SELECTION OF SPEEDS AND FEEDS
11. CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES
12. N/C MACHINE SET-UP CONSIDERATIONS
13. MACHINE CONTROL LOOP AND FEEDBACK
14. POINT-TO-POINT POSITIONING SYSTEMS
15. POSITIONING AND STRAIGHT-CUT SYSTEMS
16. CONTINUOUS PATH CONTOURING SYSTEMS
17. COMBINATION P-T-P AND CONTOURING SYSTEMS
18. MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS
1
2
3
4
5
IMPORTANCE SCALE

RELATIVE VALUE OF IMPORTANCE

1 - NO IMPORTANCE
2 - LIMITED IMPORTANCE
3 - MODERATE IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
5 - GREAT IMPORTANCE

INDUSTRIAL MEANS - - - - -
EDUCATIONAL MEANS ———

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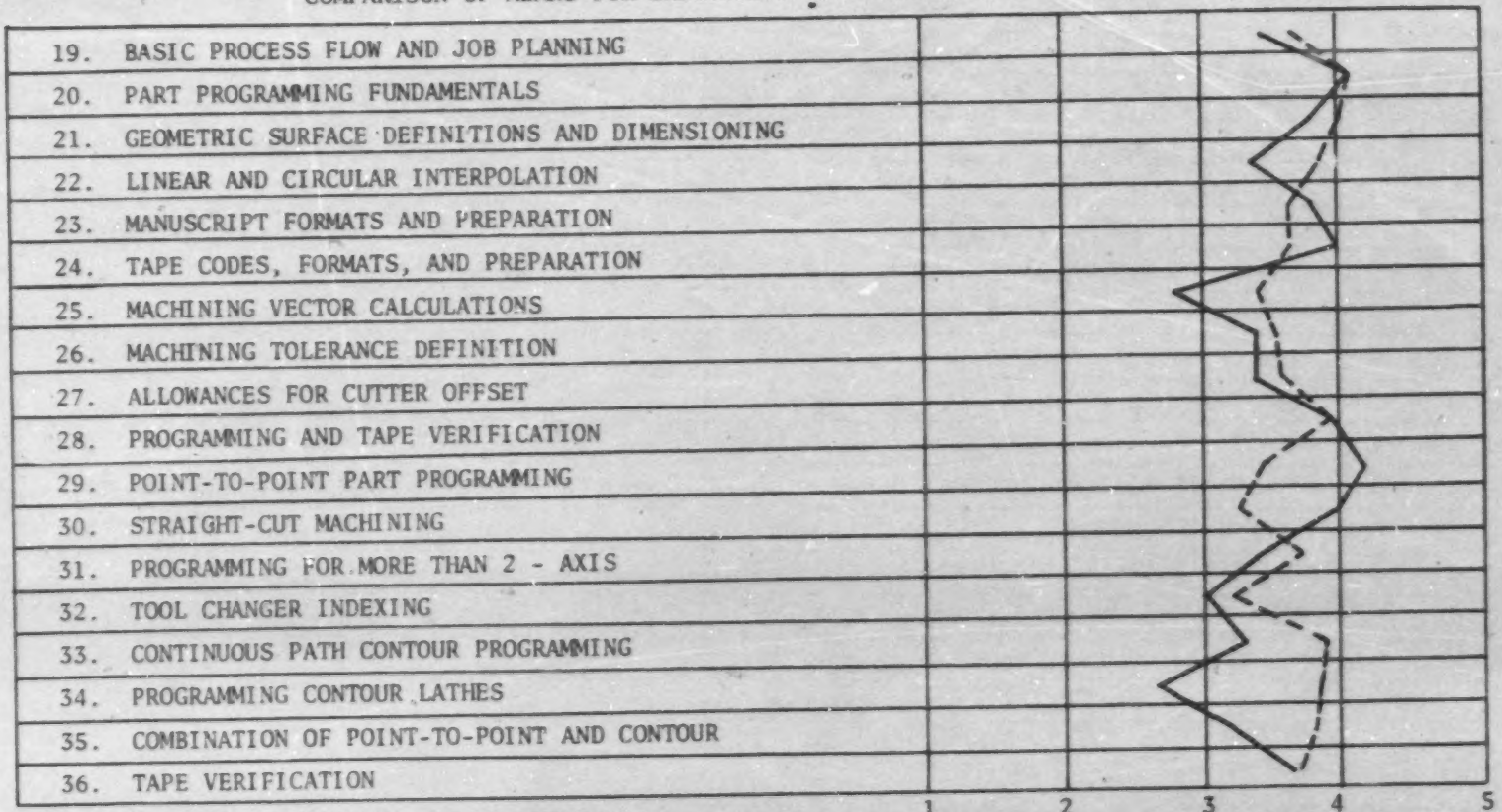
FIGURE 19

NC/ CAM TRAINING TOPIC INVENTORY: AREA 2 MANUAL PROGRAMMING
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES



RELATIVE VALUE OF IMPORTANCE

1 - NO IMPORTANCE
2 - LIMITED IMPORTANCE
3 - MODERATE IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
5 - GREAT IMPORTANCE

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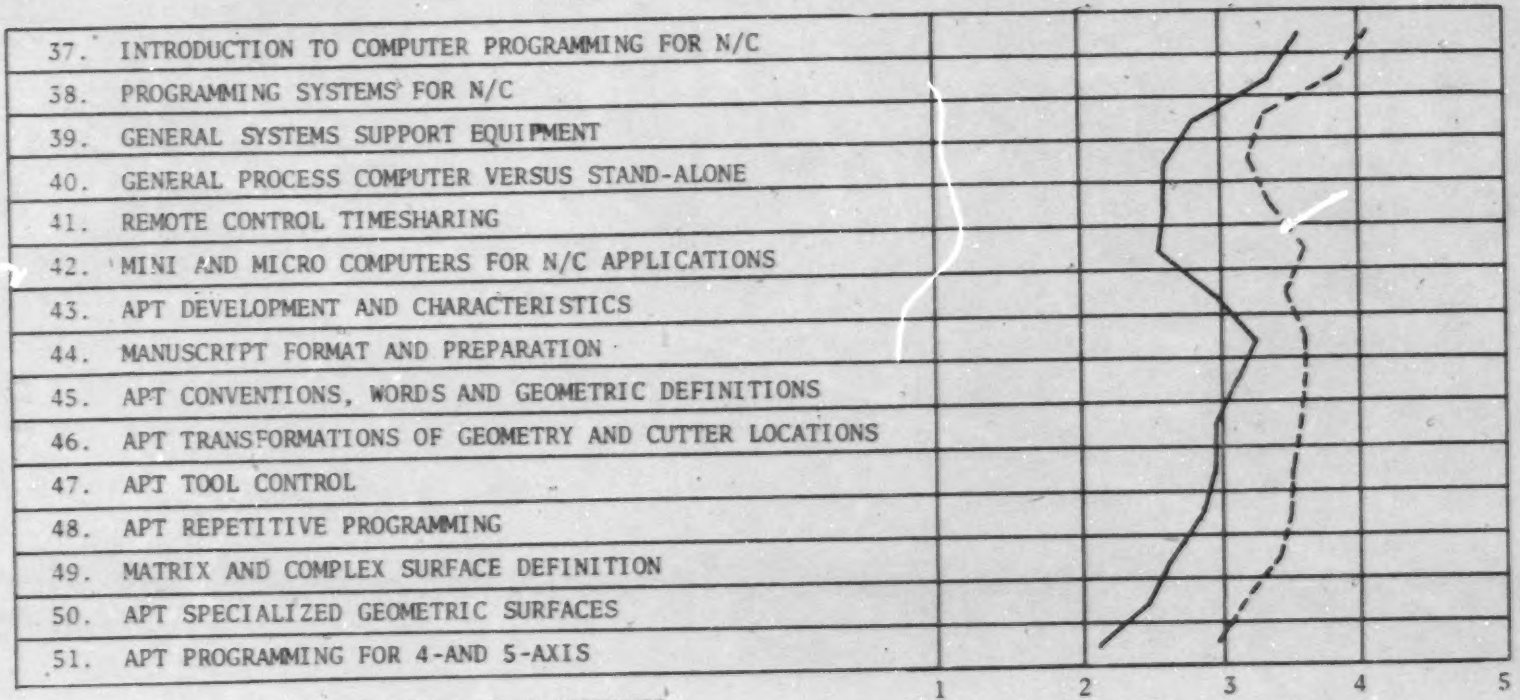
respect to the value of specific topics is reflected. Only four items have a higher rating in the educational group compared to the industrial group. These items were: (23) Manuscript Formats and Preparation; (24) Tape Codes, Formats, and Preparation; (29) Point-To-Point Part Programming; and (30) Straight-Cut Machining. Another noteworthy difference showed item (34) Programming Contour Lathes of lowest ranking value among educators contrasting it with one of the highest ranking items in the industry group. These differences were also confirmed when analyzing the current N/C programming practices in educational programs compared with actual practices and requirements in industry.

Finally, Figures 20, 21, and 22 contrast the mean responses for Areas III, IV, and V respectively, which concern Computer Programming, Management Aspects of N/C, and Advanced Technologies. Considerable differences between industrialist's and educator's perceptions of the importance of these areas are apparent, resulting in a consistently higher rating of all items by industry respondents. These differences generally amounted to an average of between 0.5 and 1.0 points on the importance scale.

However, despite the obvious point value differences between the two survey groups, a distinct parallel trend can be observed for a large number of items, pointing to a certain concensus on the importance of individual topics relative to each other. Thus, although the absolute value assigned to specific items varies considerably

FIGURE 20

NC / CAM TRAINING TOPIC INVENTORY: AREA 3 COMPUTER ASSISTED PROGRAMMING
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES


37. INTRODUCTION TO COMPUTER PROGRAMMING FOR N/C
38. PROGRAMMING SYSTEMS FOR N/C
39. GENERAL SYSTEMS SUPPORT EQUIPMENT
40. GENERAL PROCESS COMPUTER VERSUS STAND-ALONE
41. REMOTE CONTROL TIMESHARING
42. MINI AND MICRO COMPUTERS FOR N/C APPLICATIONS
43. APT DEVELOPMENT AND CHARACTERISTICS
44. MANUSCRIPT FORMAT AND PREPARATION
45. APT CONVENTIONS, WORDS AND GEOMETRIC DEFINITIONS
46. APT TRANSFORMATIONS OF GEOMETRY AND CUTTER LOCATIONS
47. APT TOOL CONTROL
48. APT REPETITIVE PROGRAMMING
49. MATRIX AND COMPLEX SURFACE DEFINITION
50. APT SPECIALIZED GEOMETRIC SURFACES
51. APT PROGRAMMING FOR 4-AND 5-AXIS
1
2
3
4
5
RELATIVE VALUE OF IMPORTANCE
IMPORTANCE SCALE
1 - NO IMPORTANCE
2 - LIMITED IMPORTANCE
3 - MODERATE IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
5 - GREAT IMPORTANCE
INDUSTRIAL MEANS
EDUCATIONAL MEANS

149

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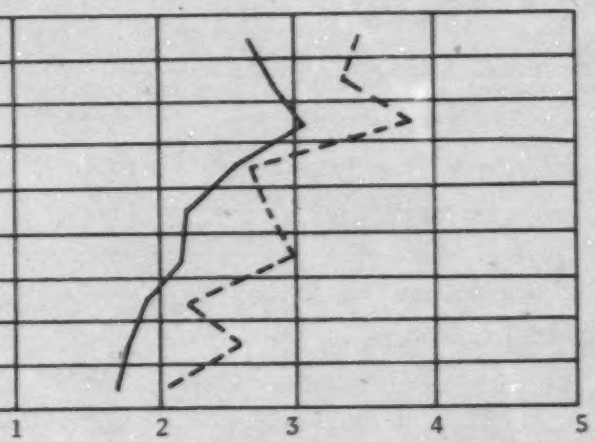
FIGURE 20 (CONT.)

NC / CAM TRAINING TOPIC INVENTORY: AREA 3 COMPUTER ASSISTED PROGRAMMING
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES

52.	POST PROCESSOR DEFINITIONS AND ELEMENTS
53.	PROCESSING THE APT PART PROGRAM
54.	PROGRAM DEBUGGING PROCEDURES
55.	ADAPT: ADAPTATION OF APT BY IBM
56.	UNIAPT: UNITED COMPUTING CORPORATION APT
57.	COMPACT II: MANUFACTURING DATA SYSTEMS INC., MDSI
58.	SPLIT: SUNDSTRAND PROCESS. LANG. INTERNALLY TRANSLATED
59.	ACTION: MANUFACTURING DATA SYSTEMS, INC., MDSI
60.	NUFORM: A.S. THOMAS, INC.



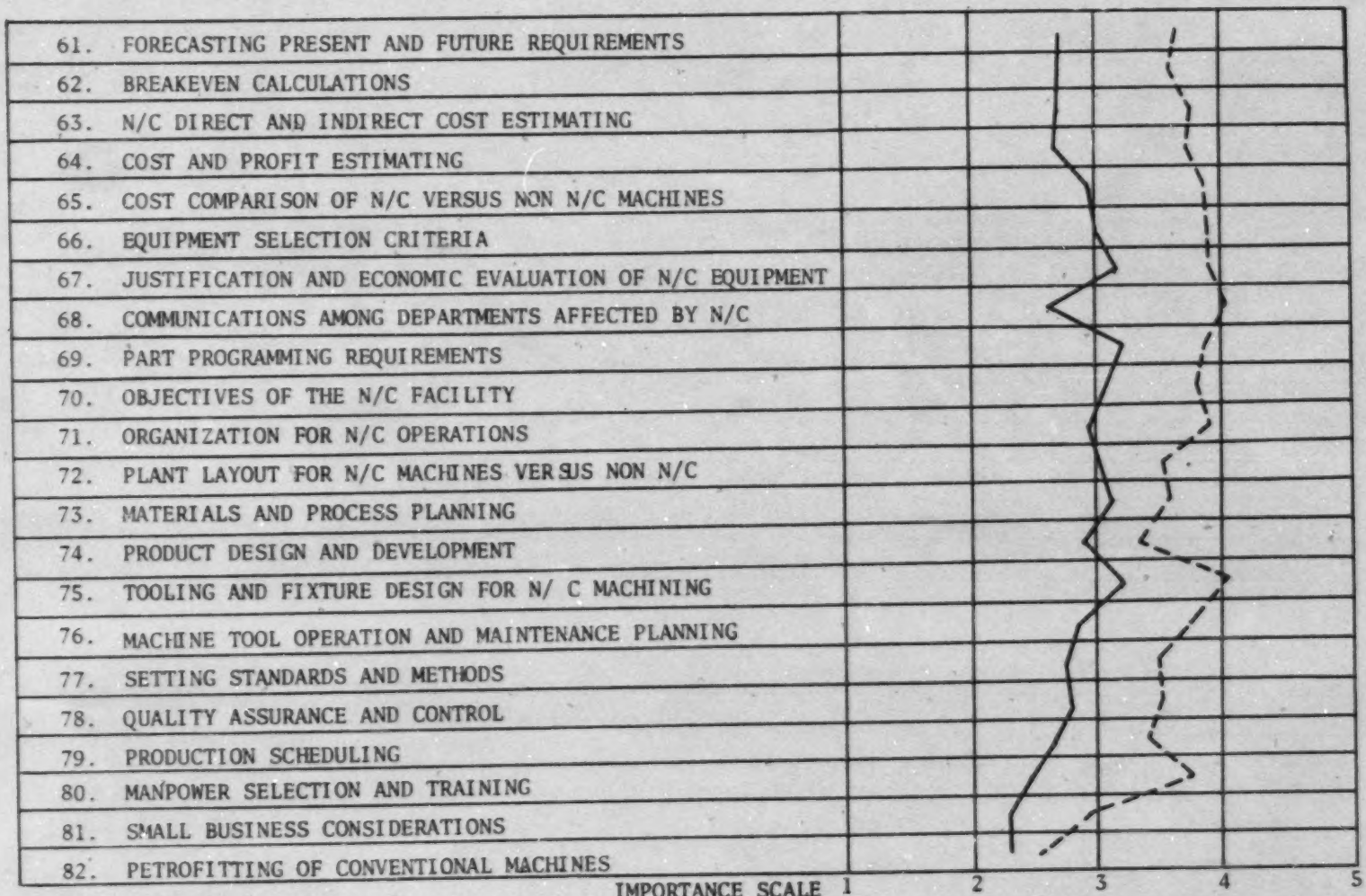
RELATIVE VALUE OF IMPORTANCE

IMPORTANCE SCALE

1 - NO IMPORTANCE
2 - LIMITED IMPORTANCE
3 - MODERATE IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
5 - GREAT IMPORTANCE

INDUSTRIAL MEANS - - - -
EDUCATIONAL MEANS ———

FIGURE 21 : NC / CAM TRAINING TOPIC INVENTORY: AREA 4 MANAGEMENT ASPECTS
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES


61. FORECASTING PRESENT AND FUTURE REQUIREMENTS
62. BREAKEVEN CALCULATIONS
63. N/C DIRECT AND INDIRECT COST ESTIMATING
64. COST AND PROFIT ESTIMATING
65. COST COMPARISON OF N/C VERSUS NON N/C MACHINES
66. EQUIPMENT SELECTION CRITERIA
67. JUSTIFICATION AND ECONOMIC EVALUATION OF N/C EQUIPMENT
68. COMMUNICATIONS AMONG DEPARTMENTS AFFECTED BY N/C
69. PART PROGRAMMING REQUIREMENTS
70. OBJECTIVES OF THE N/C FACILITY
71. ORGANIZATION FOR N/C OPERATIONS
72. PLANT LAYOUT FOR N/C MACHINES VERSUS NON N/C
73. MATERIALS AND PROCESS PLANNING
74. PRODUCT DESIGN AND DEVELOPMENT
75. TOOLING AND FIXTURE DESIGN FOR N/ C MACHINING
76. MACHINE TOOL OPERATION AND MAINTENANCE PLANNING
77. SETTING STANDARDS AND METHODS
78. QUALITY ASSURANCE AND CONTROL
79. PRODUCTION SCHEDULING
80. MANPOWER SELECTION AND TRAINING
81. SMALL BUSINESS CONSIDERATIONS
82. PETROFITTING OF CONVENTIONAL MACHINES
IMPORTANCE SCALE 1 2 3 4 5

153

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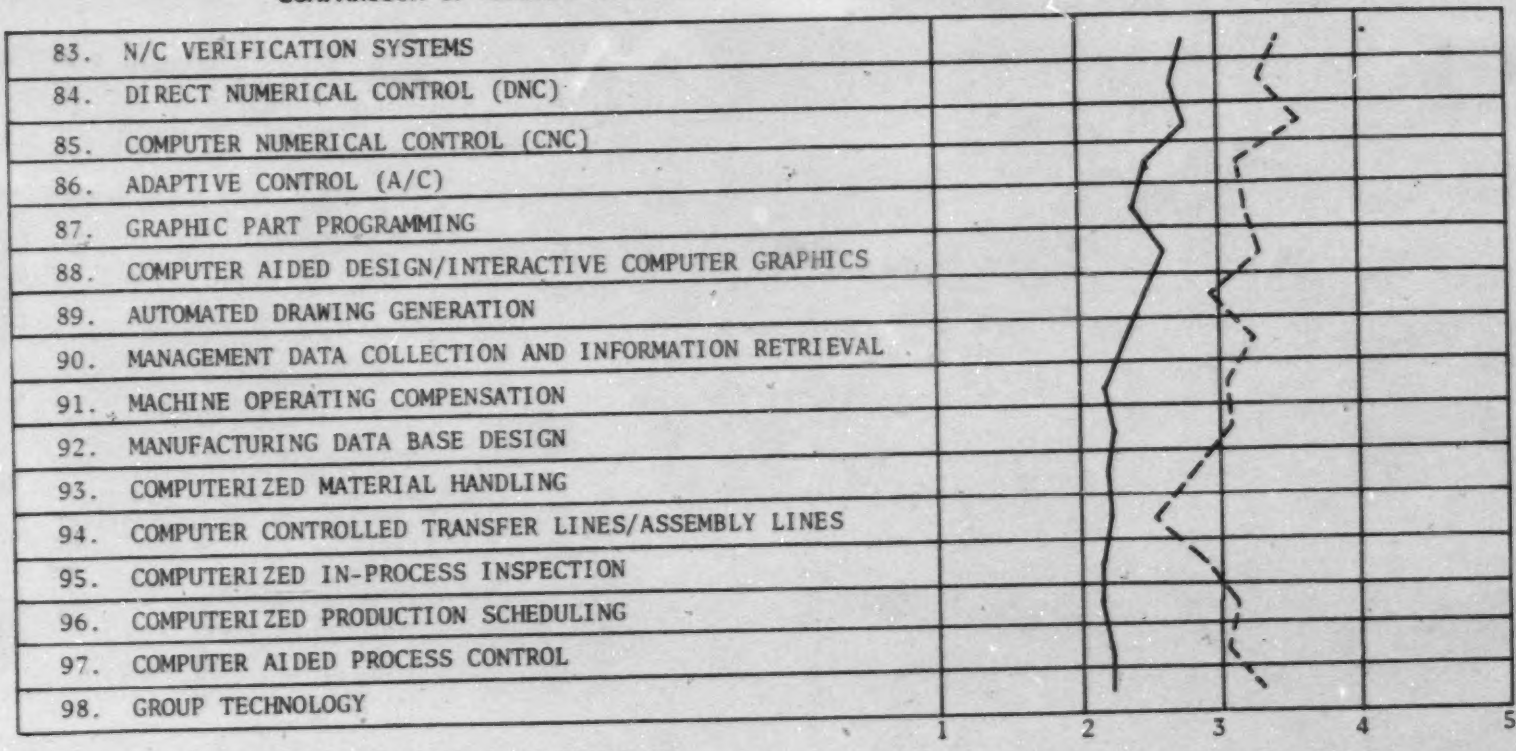
FIGURE 22

NC / CAM TRAINING TOPIC INVENTORY: AREA 5 ADVANCED TECHNOLOGIES
COMPARISON OF MEANS FOR INDUSTRIAL AND EDUCATIONAL RESPONSES



RELATIVE VALUE OF IMPORTANCE

1 - NO IMPORTANCE
2 - LIMITED IMPORTANCE
3 - MODERATE IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
5 - GREAT IMPORTANCE

IMPORTANCE SCALE

INDUSTRIAL MEANS — — — —
EDUCATIONAL MEANS ————

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between the respondent groups, a similarity in relative priorities can be discerned.

In summary, it should be noted that significant differences of perception exist between industry and education, with a certain degree of relative similarity in trend. The considerable degree of lower ratings on the majority of items by education compared to industry requires a reexamination of required priority areas for curriculum development in N/C instruction. (For a detailed statistical analysis of significant differences in means, refer to analysis of Variance Table listing F-Ratio and P-Probability based on Veldman's program ANOVAR in Appendix H).

Industrial and Educational Means by Area

For the purpose of summarizing the contrast of industrial and educational responses to the NC/CAM Training Topic Inventory, Figures 23 and 24, illustrate the individual industrial and educational group mean responses and standard deviations of the two groups on an area-by-area basis. In analyzing these figures, the differences in importance ratings as well as the similarities in general trend became more apparent. Generally, it can be said that the variation in responses, as measured by the corresponding standard deviations was larger for the educational group with an average of 1.1662 as compared to 1.045 for respondents from industry.

FIGURE 23

INDUSTRIAL MEAN RESPONSES TO NC/CAM TRAINING TOPIC INVENTORY BY AREA
(BASED ON 492 (98%) COMPLETED RESPONSES)

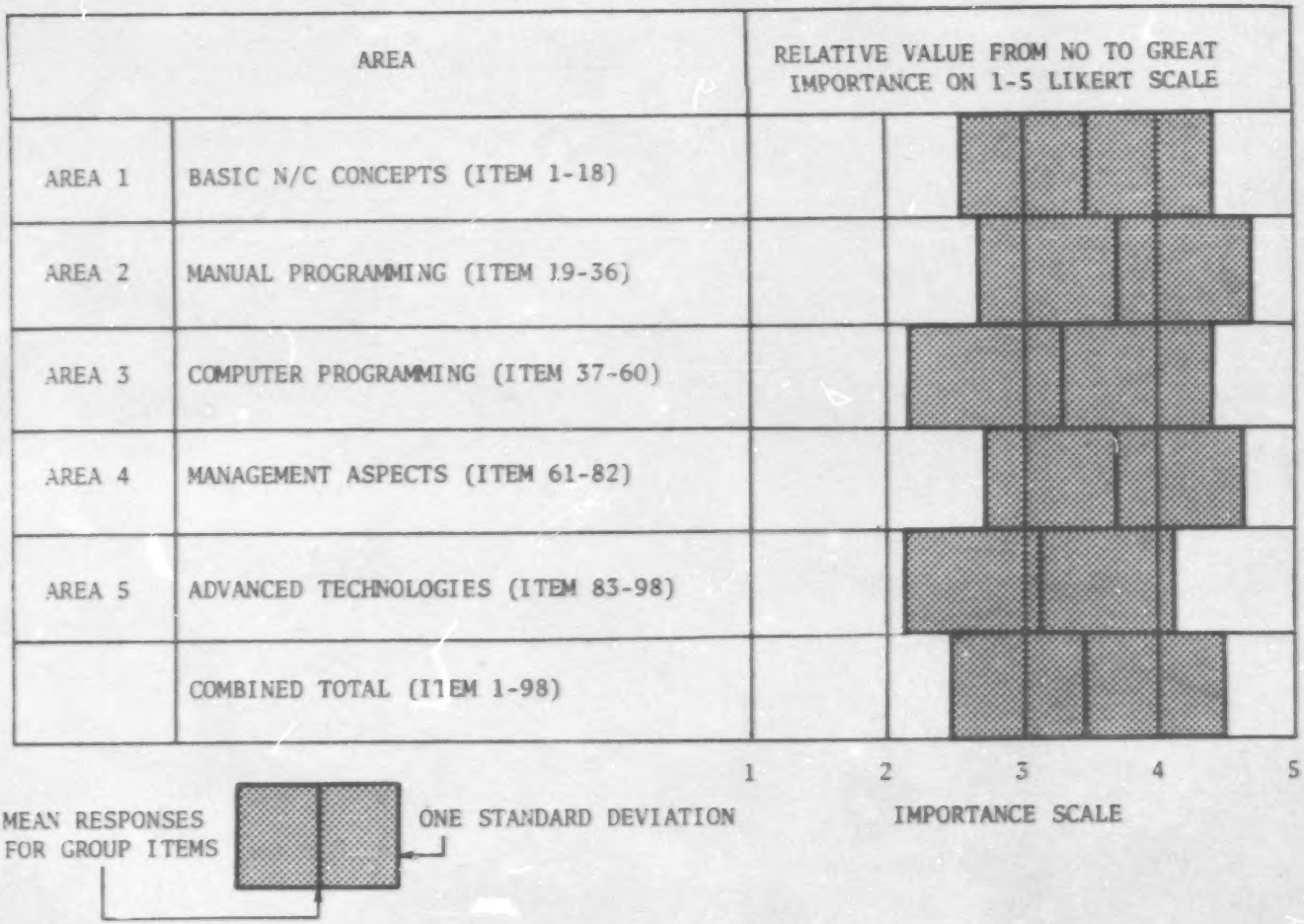


FIGURE 24

EDUCATIONAL MEAN RESPONSES TO NC/CAM TRAINING TOPIC INVENTORY BY AREA
(BASED ON 492 (98%) COMPLETED RESPONSES)

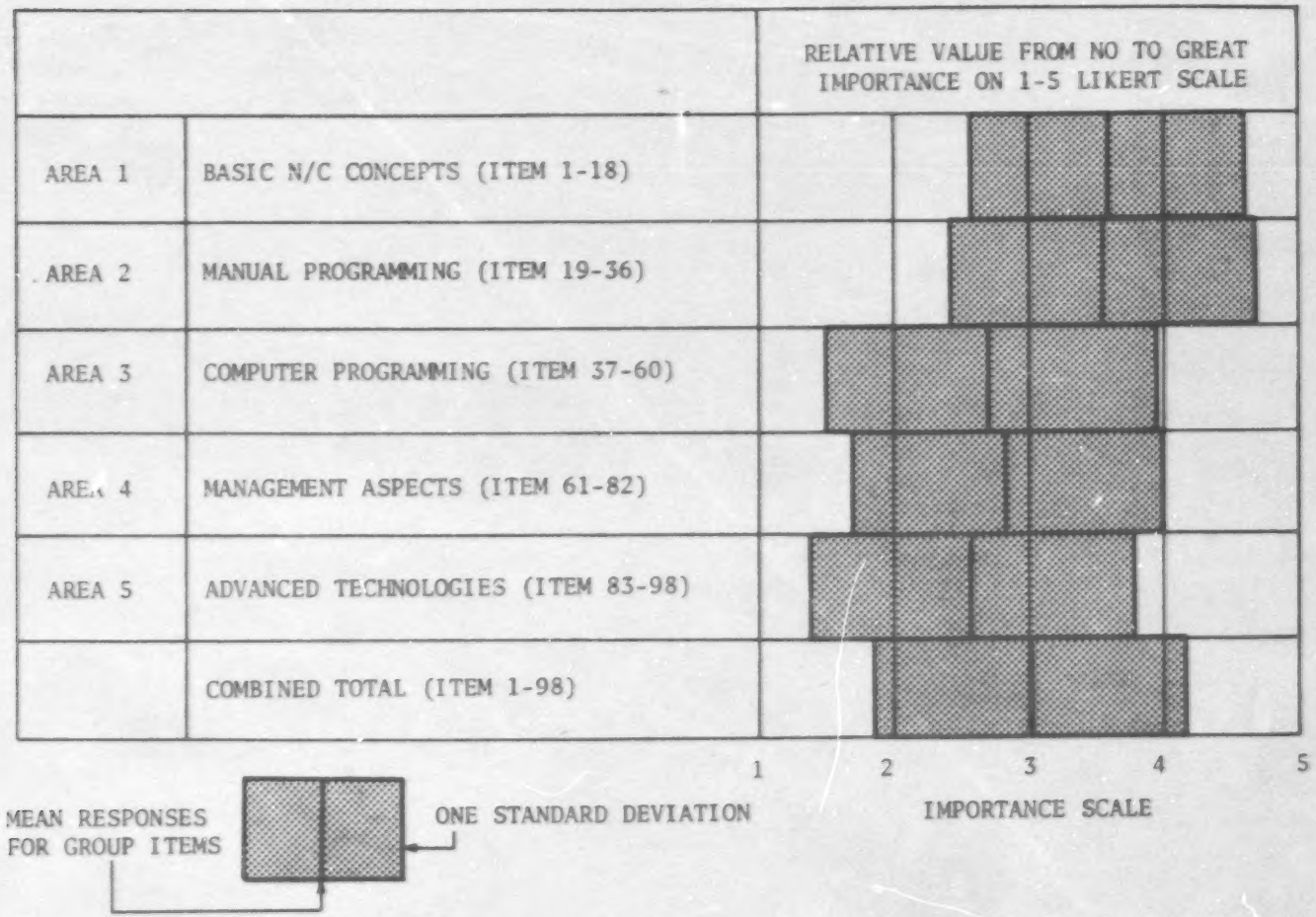


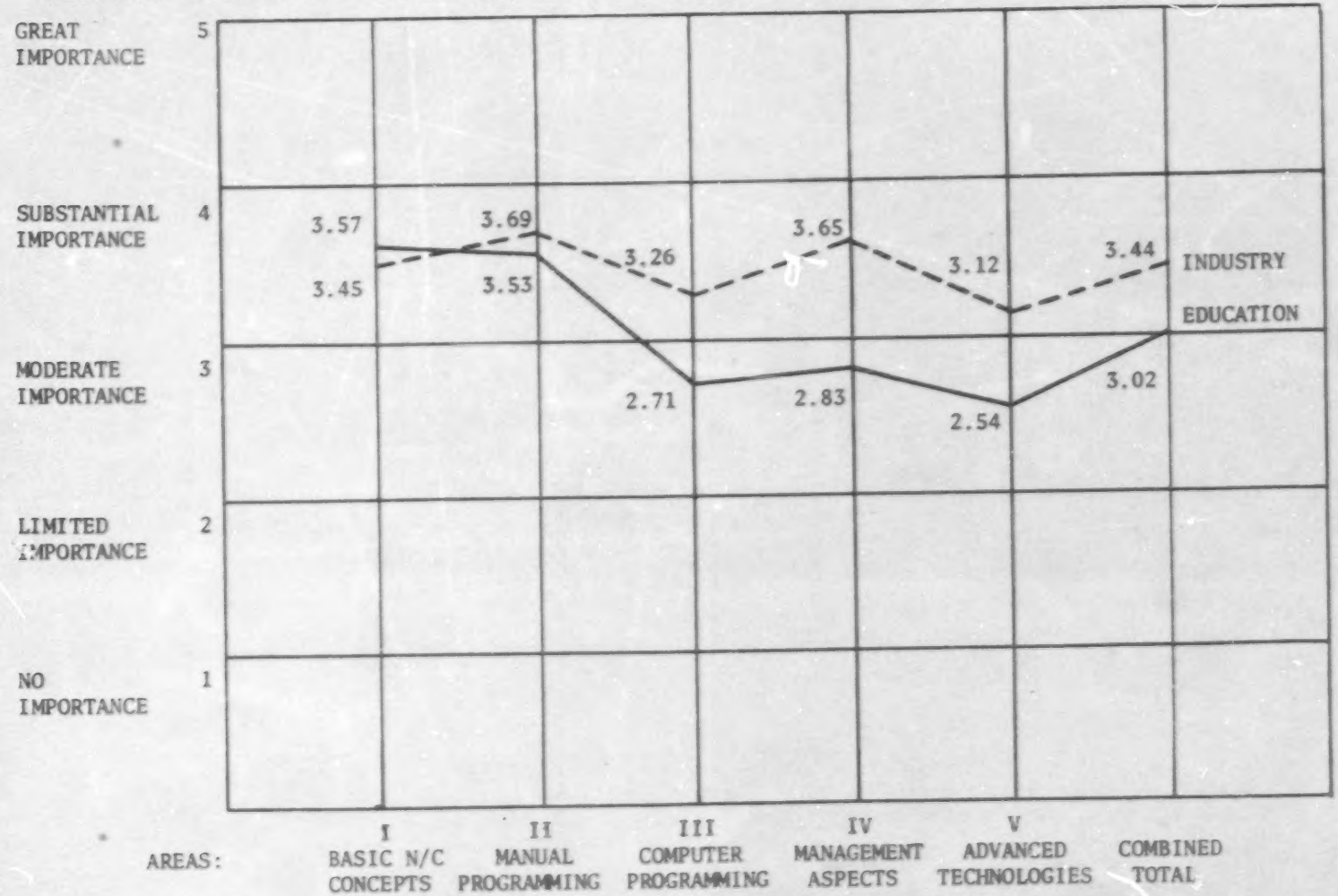
Figure 25 contrasts the individual area and combined total response means for both groups. Three of the five areas were rated lower than moderate importance by educators with overall means of 2.7142 for Computer Programming, 2.8333 for Management Aspects of N/C, and 2.5386 for Advanced Technologies. This resulted in considerably lower ratings than those by industrialists. The corresponding importance ratings by the industrial group were as follows: Computer Programming 3.2612, Management Aspects of N/C 3.6532, and Advanced Technologies 3.1275.

One area, however, Area I Basic N/C Concepts, was rated slightly higher by educators with 3.5725 compared with 3.4543 by industrialists. Area II, Manual Programming, showed only slight differences with a mean of 3.6927 rated by industry participants compared with 3.5257 by educators.

The combined total importance ratings for the NC/CAM Training Topic Inventory resulted in 3.4421 for the industry group compared with 3.0190 for the education group. Consequently, the significance of these mean response comparisons can be found particularly in the generally higher industry ratings, with all five areas considered in the range of moderate to substantial importance contrasting with only two areas, Basic N/C Concepts and Manual Programming receiving similar results in the education group.

FIGURE 25

COMPARISON OF INDUSTRIAL AND EDUCATIONAL MEAN RESPONSES TO NC/CAM TRAINING TOPIC INVENTORY BY AREA



Statistical Analysis of Group Responses

In order to identify any statistically significant differences, correlations, or variations in responses to the NC/CAM Training Topic Inventory due to the different groups of respondents and characteristics of their educational institutions or industrial organizations, a statistical analysis of these variables was carried out. The specific statistical procedures applied, included a correlation and factor analysis of the variables concerned and are described below.

Correlation of Respondents and Responses

Veldman's program for factor analysis FACTOR (1967, pp. 219-221) was used to derive the correlation matrix pertinent to the particular response variables involved. Table 22 presents the correlations of type of respondent (industrial or educational groups) with the responses to the five main areas of the survey instrument. All area responses correlated highly with each other as well as with the total responses with a significant value beyond the .01 level of confidence. Although a limited negative correlation of most area responses with type of respondent was noted, it was not statistically significant, but pointed to some differences in respondent groups.

Consequently, a further analysis was conducted independently for the two main survey groups for the purpose of determining any significant differences or possible correlations of dependent and independent

TABLE 22

CORRELATION COEFFICIENTS BETWEEN TYPE OF RESPONDENT (INDUSTRIAL OR EDUCATIONAL) AND RESPONSES TO THE NC/CAM TRAINING TOPIC INVENTORY

Variables	Type of Respondent	Basic N/C Concepts	Manual Programming	Computer Programming	Management Aspects	Advanced Technologies	Total
Type of Respondent	1.0000	-0.0816	-0.0076	-0.0250	0.0802	-0.0137	-0.0040
Basic N/C Concepts	- -	1.0000	0.6230**	0.3749**	0.4171**	0.2784**	0.6560**
Manual Programming	- -	- -	1.0000	0.4496**	0.4649**	0.2216**	0.7038**
Computer Programming	- -	- -	- -	1.0000	0.5503**	0.5872**	0.8280**
Management Aspects	- -	- -	- -	- -	1.0000	0.5777**	0.8232**
Advanced Technologies	- -	- -	- -	- -	- -	1.0000	0.7273**
Total	- -	- -	- -	- -	- -	- -	1.0000

*r - .09 significant at the .05 level
**r - .12 significant at the .01 level

variables. Table 23 lists the correlation coefficients of selected variables for the industrial respondents. These variables include, apart from the area responses to the instrument, the following independent variables: (1) Type of Industry, (2) Position of Respondent, (3) Geographic Location, and (4) Size of Company. (See code sheet for identification of above variables in Appendix J).

The respective correlation coefficients are identified according to their level of significance for each pair of variables concerned. For example, Table 23 shows that the size of the company positively correlated with the type of industry and the position of the respondents. On the other hand, the position of the respondent negatively correlated with responses to Area I, Basic N/C Concepts, and Area II, Manual Programming at the .05 significance level. These correlations indicate that there is a significant difference in the responses to these particular areas among industrial respondents based on their position in the company.

Size of company also correlated negatively with Area II, Manual Programming, responses at the .05 significance level and positively at the .01 significance level with responses to Area V, Advanced Technologies. This may indicate less importance of manual programming applications and an increasing importance of advanced technologies in large companies. All area responses correlated significantly with each other as well as with the total responses, at the .01 significance level.

TABLE 23

CORRELATION COEFFICIENTS OF SELECTED VARIABLES OF INDUSTRIAL RESPONDENTS AND RESPONSES TO THE NC/CAM TRAINING TOPIC INVENTORY

Variables	Type of Industry	Position of Respondent	Geographic Location	Size of Company	Basic N/C Concepts	Manual Programming	Computer Programming	Management Aspects	Advanced Technologies	Total Responses
Type of Industry	1.0000	0.1001*	0.0010	0.2563**	-0.1006*	-0.0411	-0.0665	0.0144	-0.0730	-0.0692
Position of Respondent	- -	1.0000	-0.0589	0.1846**	-0.1023*	-0.0931*	-0.0018	-0.0418	-0.0287	-0.0659
Geographic Location	- -	- -	1.0000	0.0345	0.0016	-0.0575	0.0055	0.0320	0.0295	0.0038
Size of Company	- -	- -	- -	1.0000	-0.0774	-0.1038*	0.0713	-0.0336	0.1441**	0.0095
Basic N/C Concepts	- -	- -	- -	- -	1.0000	0.5765**	0.4020**	0.4813**	0.3229**	0.7177**
Manual Programming	- -	- -	- -	- -	- -	1.0000	0.4251**	0.4450**	0.1856**	0.7075**
Computer Programming	- -	- -	- -	- -	- -	- -	1.0000	0.4006**	0.4920**	0.7820**
Management Aspects	- -	- -	- -	- -	- -	- -	- -	1.0000	0.4531**	0.7617**
Advanced Technologies	- -	- -	- -	- -	- -	- -	- -	- -	1.0000	0.6792**
Total Responses	- -	- -	- -	- -	- -	- -	- -	- -	- -	1.0000

*r = .09 significant at the .05 level
**r = .12 significant at the .01 level

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Table 24 presents the corresponding correlation coefficients of similar variables for the educational group respondents. These are the following: (1) Type of Institution, (2) Position of Respondent, (3) Geographic Location, (4) Size of Department, as well as the five area and total responses to the survey instrument. A negative correlation existed between type of institution and position of respondent and size of department at the .05 and .01 significance levels respectively. (See Appendix J for code sheet identification of variables).

A noticeable positive correlation also existed between position of respondent and all but one area (Manual Programming) indicating a strong correlation of certain types of respondents and their respective responses to the NC/CAM Training Topic Inventory. However, size of department did not appear to influence the responses to the survey instrument. Similar to the industrial group, the educational group also confirmed the pronounced correlation of all area responses with each other as well as with the total responses. With the exception of the two correlations: Advanced Technologies with Basic N/C Concepts and Manual Programming at the .05 significance level respectively, all other area correlations were at the .01 significance level.

In conclusion it can be stated that both survey groups revealed significant correlations among most variables concerning area and total instrument responses. Some correlations and variations based on differences of respondent group characteristics also became apparent.

TABLE 24

CORRELATION COEFFICIENTS OF SELECTED VARIABLES OF EDUCATIONAL RESPONDENTS AND RESPONSES TO THE NC/CAM TRAINING TOPIC INVENTORY

Variables	Type of Institution	Position of Respondent	Geographic Location	Size of Department	Basic N/C Concepts	Manual Programming	Computer Programming	Management Aspects	Advanced Technologies	Total Responses
Type of Institution	1.0000	-0.1992	0.0996	-0.4040	-0.0363	-0.0191	-0.0890	-0.0052	-0.0094	-0.0448
Position of Respondent	- -	1.0000	-0.0618	0.1454	0.2009*	0.1298	0.2478*	0.2751**	0.2741**	0.2923**
Geographic Location	- -	- -	1.0000	-0.1803	-0.2497	-0.1843	-0.1223	-0.1482	-0.1509	-0.2023
Size of Department	- -	- -	- -	1.0000	0.1650	0.0696	0.0678	0.0152	0.0800	0.0891
Basic N/C Concepts	- -	- -	- -	- -	1.0000	0.8069**	0.3536**	0.4083**	0.1750*	0.6243**
Manual Programming	- -	- -	- -	- -	- -	1.0000	0.4500**	0.4590**	0.2134*	0.6883**
Computer Programming	- -	- -	- -	- -	- -	- -	1.0000	0.7091**	0.7348**	0.8809**
Management Aspects	- -	- -	- -	- -	- -	- -	- -	1.0000	0.7665**	0.8855**
Advanced Technologies	- -	- -	- -	- -	- -	- -	- -	- -	1.0000	0.7863**
Total Responses	- -	- -	- -	- -	- -	- -	- -	- -	- -	1.0000

*r = .195 significant at the .05 level
**r = .254 significant at the .01 level

Factor Analysis of Response Variables

After determining any correlations and/or significant differences among the individual response variables, those factors were identified which accounted for the most variance among the responses to the survey instrument. For that purpose, Veldman's program FACTOR (1967, pp.219-221) was applied to carry out the appropriate factor analysis. This program bases the analysis on the intercorrelation matrix by using unities in the diagonals as commonalities of variables. With the eigenvalue set at unity (1.0), only factors greater than one are calculated. Those are the factors which account for the largest percentage of variance among the variables.

Table 25 presents the principal factor pattern for both survey respondent groups and the five area and total responses with a combined variance of 69.75 percent. Factor I, the instrument ratings, accounting for 53.81 percent of the variance, consisted exclusively of the survey responses, with factor II, the Type of Respondent, representing only 15.91 percent of the total variance. This indicates that the individual area responses provided the most variation whereas the different respondents played only a secondary role.

Table 26 illustrates the main factors which contributed 61.59 percent of the total variance among industrial respondents, according to their specific characteristics and responses. As the table indicates, Factor I, the instrument ratings, again was entirely composed of variables representing area and total responses with 36.75 percent of

TABLE 25

PRINCIPAL FACTOR PATTERN FOR COMBINED RESPONDENTS AND FIVE MAIN AREAS OF NC/CAM TOPIC INVENTORY

Variable	Factors*	
	I	II
1. Type of Respondent		0.8340
2. Basic N/C Concepts	0.6287	
3. Manual Programming	0.6729	
4. Computer Programming	0.8132	
5. Management Aspects	0.8371	
6. Advanced Technologies	0.7480	
7. Total Responses	0.9927	
Percent of Factor Variance	53.81%	15.91%
Percent of Total Variance	61.59%	

*NOTE: Only loadings greater than .400 are included.

TABLE 26

PRINCIPAL FACTOR PATTERN FOR INDUSTRIAL RESPONDENTS AND FIVE MAIN AREAS OF NC/CAM TOPIC INVENTORY

Variable	Factors*		
	I	II	III
1. Type of Industry		0.5995	
2. Position of Respondent		0.5573	
3. Geographic Location			0.9046
4. Size of Company		0.7829	
5. Basic N/C Concepts	0.7402		
6. Manual Programming	0.7027		
7. Computer Programming	0.7633		
8. Management Aspects	0.7632		
9. Advanced Technologies	0.6803		
10. Total Responses	0.9985		
Percent of Factor Variance	36.75%	14.33%	10.51%
Percent of Total Variance		61.59%	

*NOTE: Only loadings greater than .400 are included.

total variance. Factor II, respondent characteristics, contributed 14.33 percent of the variance consisting of the following variables: Type of Industry, Respondent Position, and Size of Company. Factor III, Geographic Location, accounted for an additional 10.51 percent of the total variance.

Finally, Table 27 presents the principal factor patterns for the educational respondents and their respective responses. In this case, only three of the area responses and the combined responses accounted for most of the overall variance, specifically 33.59 percent for Factor I, instrument ratings, with Advanced Technologies contributing the most variance. Thus, the combination of those four individual variables together were the strongest measure of total variance with Factor II, respondent characteristics, adding 15.40 percent variance. However, this factor was bipolar with both positive and negative significant loadings. The Type of Institution was a variable contributing to the variance whereas the position of the respondent and the size of department did not contribute to the total variance.

Factor III, also bipolar with an additional three variables, contributed 21.80 percent of the total variance consisting of the variables: Geographic Location, Basic N/C Concepts, and Manual Programming. The negative loading of the latter two variables indicated that the variance contributed by this factor was not dependent on responses to Basic N/C Concepts and/or Manual Programming which, in effect, showed the least variation among all respondents in the educational group.

TABLE 27

PRINCIPAL FACTOR PATTERN FOR EDUCATIONAL RESPONDENTS AND FIVE MAIN AREAS OF NC/CAM TOPIC INVENTORY

Variable	Factors*		
	I	II	III
1. Type of Institution		0.8086	
2. Position of Respondent		-0.4182	
3. Geographic Location			0.4081
4. Size of Department		-0.7834	
5. Basic N/C Concepts			-0.9092
6. Manual Programming			-0.8848
7. Computer Programming	0.8600		
8. Management Aspects	0.8695		
9. Advanced Technologies	0.9226		
10. Total Responses	0.8608		
Percent of Factor Variance	33.59%	15.40%	21.80%
Percent of Total Variance		70.81%	

*NOTE: Only loadings greater than .400 are included.

Rank Order Comparison of Highest Ranking Training Topics and Areas

In order to summarize the results of this nationwide survey with respect to their relevancy and implications for curriculum development, a final comparison of the views and perceptions of the two main survey groups from industry and education was carried out in the following manner. After analyzing all responses to the instrument on an item by item basis, as well as by area, all items on the NC/CAM Training Topic Inventory were ranked according to their mean response ratings on the five point importance scale for each main survey group separately. (See Appendix I for detailed lists of Industrial and Educational Group Rank Order of the Means).

Subsequently, an overall item ranking based on each group's responses identified all N/C topics that were rated of moderate (mean = 3.00), substantial (mean = 4.00), or of higher importance. This analysis resulted in a listing of 73 items (75 percent of the instrument) considered to be of importance for educational programs in N/C. Finally, these 73 highest ranking items were regrouped into the original five main areas within three consecutive levels of importance for each of the two main groups. However, instead of listing the individual items, each level was composed of the respective percentage representation of each of the five areas within each level.

Figure 26 illustrates the graphical comparison of the industrial and educational group responses for the highest ranking 75 percent items

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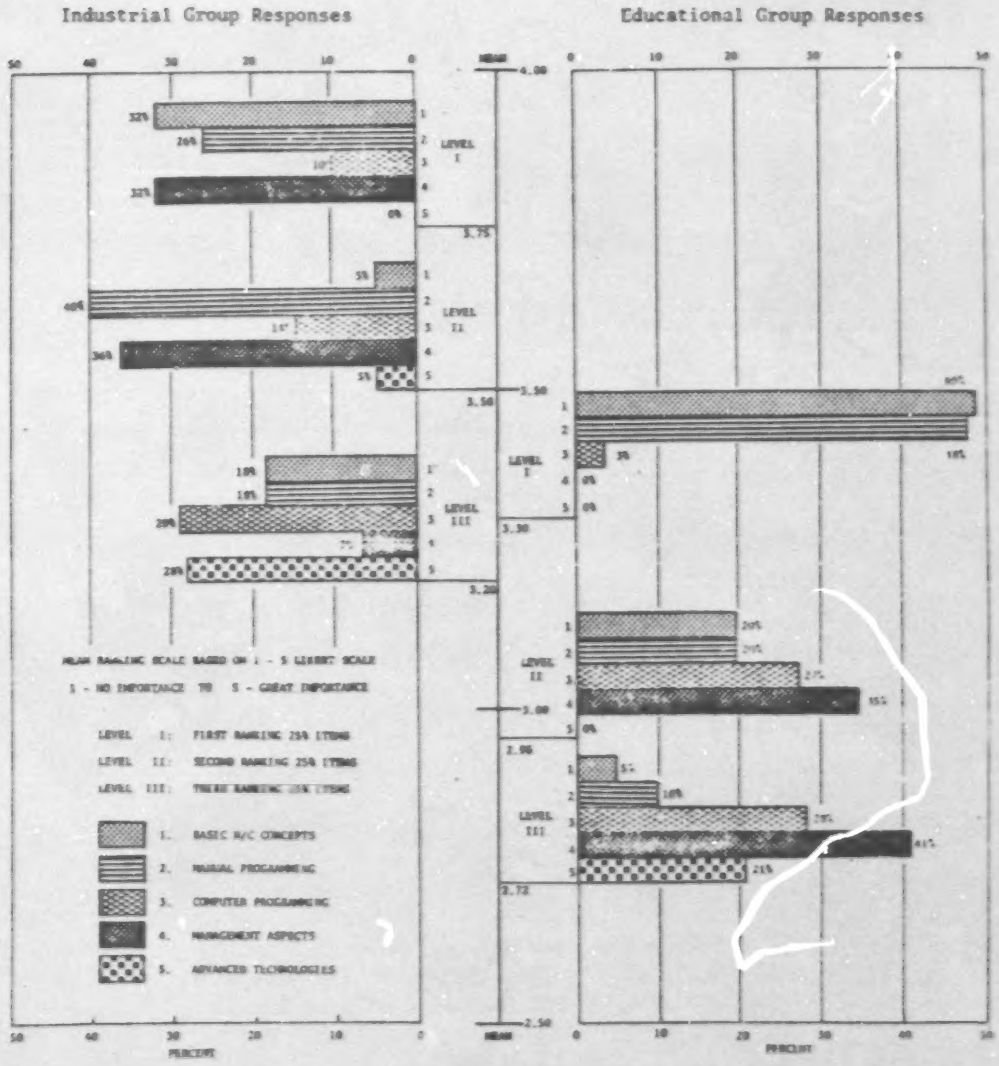
FIGURE 26

RANK ORDER COMPARISON OF HIGHEST RANKING TRAINING TOPICS AND AREAS
BY LEVELS FOR INDUSTRIAL AND EDUCATIONAL GROUPS



according to their distribution within the five main areas. The breakdown into three consecutive levels consisted of: (1) Level I, highest ranking 25 percent of the items, (2) Level II, second highest ranking 25 percent of all items, and (3) Level III, third highest ranking 25 percent of the items.

Without listing specific items (which can be found in the rank order of the means in Appendix I), each level consists of that part of the five main topic areas that was rated accordingly on the mean ranking scale. In order to account for unequal item numbers within areas, the percentages were adjusted proportionately, thus representing each area more realistically. These areas were: (1) Basic N/C Concepts, (2) Manual Programming, (3) Computer Programming, (4) Management Aspects, and (5) Advanced Technologies.

As can be seen in the illustration of Figure 26, these training topic areas are represented with varying percentages at each level as well as between corresponding levels of the two respondent groups. The significance of this comparison lies in the different levels of importance assigned to each area by industry as compared to education.

Consequently, this comparison reveals some of the differences of views concerning priority areas and topics of N/C technology for educational programs between industrial N/C users and educators. These results also point to the differences between the actual needs and requirements, as conceived by industry, and those considered important for current instruction in this technology.

Thus, based on these findings, educational priorities appear to concentrate on Basic N/C Concepts (49 percent), and Manual Programming (48 percent), representing most of the items in Level I with a mean rating value of above 3.30 on the one to five rating scale. In contrast, industrial respondents assigned a mean rating of more than 3.75 to Level I, which also includes a large proportion of Management Aspects (32 percent), and Computer Programming (10 percent), in addition to Basic N/C Concepts (32 percent), and Manual Programming (26 percent).

Although the mean rating of Level II for the education group was only between 2.95 and 3.30, the distribution of the different areas was more balanced than in Level I. It consisted of the following areas: Basic N/C Concepts (20 percent), Manual Programming (20 percent), Computer Programming (27 percent), and Management Aspects (33 percent). Level III, however, rated only above 2.72 with the educational survey participants, whereas industrial participants ranked this Level above 3.20 on the one to five mean scale. Finally, the area Advanced Technologies was ranked with 21 percent at Level III by educators as compared with five percent at Level II and 28 percent at Level III by industrialists.

In conclusion, this comparison reveals the variation in perception of what constitutes the most important tasks and topics for educational programs in NC/CAM as expressed by the two groups of survey participants. Understandably, educators place more emphasis on general and basic

concepts of this new technology, with similar importance given to manual programming techniques. However, taking into consideration the views of knowledgeable individuals in industry, a reappraisal of current educational practices, curriculum content, and methodology in this field appears to be warranted if education is to be relevant and consistent with actual industrial practices.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this research was to investigate the effects of numerical control technology and computer aided manufacturing in American industry on industrial education and engineering technology. The specific purpose was to identify a data base and rationale for curriculum development in NC/CAM through a comparison of views by industrial N/C-users and educators regarding appropriate instructional content for educational programs in this technology.

Summary

The various research activities were divided into two main phases which consisted of: (1) survey preparation and instrument development, and (2) data collection and analysis.

Through a preliminary survey among institutions of higher education, present and planned N/C-instructional programs were identified and a mailing list for the main survey was compiled. The three groups of educational survey participants consisted of: (1) industrial teacher education institutions in the United States, (2) ECPD - accredited engineering technology institutions in the United States, and (3) occupational-technical programs in junior colleges.

The survey participants from industry consisted of the following two groups: (1) members of the Numerical Control Society, and (2) members of Computer Aided Manufacturing International, Inc.

The preliminary survey, which also included industrial training services, provided exemplary curriculum material for the design of the main survey instrument. This instrument was first validated by a jury of educational and industrial experts in NC/CAM and subsequently pilot tested in various educational institutions and industrial companies in Texas. After the suggested modifications of the instrument were carried out, the nationwide survey was conducted among 1,756 N/C users in industry and 202 educational institutions, presently offering or planning to offer N/C programs The combined survey responses resulted in a total of 627 instruments returned (32 percent of the original survey sample), of which 492 instruments (28 percent of industrial sample) and 109 instruments (54 percent of educational sample) were properly completed by the participants of these two survey groups respectively.

The subsequent statistical data analysis was conducted utilizing various computer programs of Veldman's "Fortran Programming for the Behavioral Sciences" (1967). The results were detailed descriptive statistics concerning the current status of NC/CAM in American industry and instructional programs in this technology in industrial education and technology programs.

Finally, a detailed comparison and evaluation of industrialist's and educator's responses to the NC/CAM training topic inventory was conducted. This analysis provided the specific information needed to

develop a curriculum outline which suggests the major topics and areas of priority for future curriculum development in N/C technology.

Conclusions

The following conclusions, based on the analysis of the results of the survey, were drawn:

1. Present instruction in NC/CAM in industrial education and engineering technology programs, although differing considerably among institutions, does not always reflect the current status of this technology in American industry.

2. Based on the present and projected need for N/C personnel, it appears that educational institutions do not yet provide sufficient instructional programs in this new technology, particularly in the area of computer aided manufacturing. Less than ten percent of present N/C personnel received their training in numerical control technology in educational institutions.

3. Noticeable differences exist in the proportion of major N/C machine tool types used in industry and those used for instructional purposes. Whereas 25 percent of all N/C machine tools used in industry are milling machines and 30 percent are lathes, the relation in education is 65 percent and 5.5 percent respectively.

4. Differences are apparent between present N/C programming practices, techniques, and languages employed in industry and those

currently taught in education. While industry uses an average of 36 percent manual programming and 64 percent computer assisted programming, this proportion is approximately reversed in education with 69 percent and 31 percent respectively.

5. Despite different importance ratings for individual topics, both survey groups generally agreed on the value of Basic N/C Concepts and Manual Programming. The only exception was the high rating given to contour lathe programming by industrialists contrasting with the lowest rating in this topic area by educators.

6. Different value ratings were given to topics relating to the area of Computer Programming which industrial respondents generally considered more important than educators.

7. Pronounced differences in value ratings were encountered in the areas of Management Aspects and Advanced Technologies of CAD/CAM. Except for four topics, educators rated both areas of less than moderate importance compared to most topics being considered of above moderate to substantial importance by respondents from industry.

8. Finally, it was generally noted that greater variation in responses to individual topics for N/C instruction occured among the 84 respondents of the educational group as compared to the 492 respondents from industry.

Recommendations

Suggested Curriculum Outline

In order to provide a framework and rationale for detailed curriculum development in NC/CAM, the following conceptual curriculum model is presented as a general guideline. Recognizing the accelerated pace of technological advancement, particularly in computer related areas such as numerical control and computer aided manufacturing, it is advisable that any attempt at designing a relevant curriculum take into account this dynamic nature of modern technology.

Thus, the following curriculum outline should not be regarded as static but as evolutionary as the technology itself. It is the result of valuable input received from several hundred individuals knowledgeable in the teaching and application of this technology. Therefore, any creative curriculum effort in industrial education and technology, which derives its content from industry and technology, will have to continuously review the increasing technical knowledge accumulated in order to maintain its relevancy.

Since the selection of appropriate curriculum content should be based on its consistency with the objectives and goals of a particular curriculum area as well as with the purposes of specific educational programs, the outline presented here should be adapted to individual program requirements. Thus, the following suggestions for new instructional programs in NC/CAM do not refer to specific occupational

categories, but rather to the broad technical content of this technology and its relevancy for courses in industrial education and technology in general.

Figure 27 illustrates the general philosophy for the selection process of new content material for courses in NC/CAM, based on a synthesis of the views and opinions of the educators and industrialists that participated in this study. The basic concept that is being introduced with this model, although not new, is the following: in order to provide as much breadth and depth as possible, no single area should dominate the instructional program. Instead a more balanced approach which assures a more effective exposure to the variety of elements involved in this technology is suggested.

Thus, five major areas of NC/CAM are presented in three levels, from introductory, to intermediate, and advanced programs with the specific number of courses required determined by the particular needs and purposes of the institution and its students. These five main areas are the following:

(1) Basic and General N/C Concepts

(2) Manual Numerical Control Programming

(3) Computer Assisted Programming

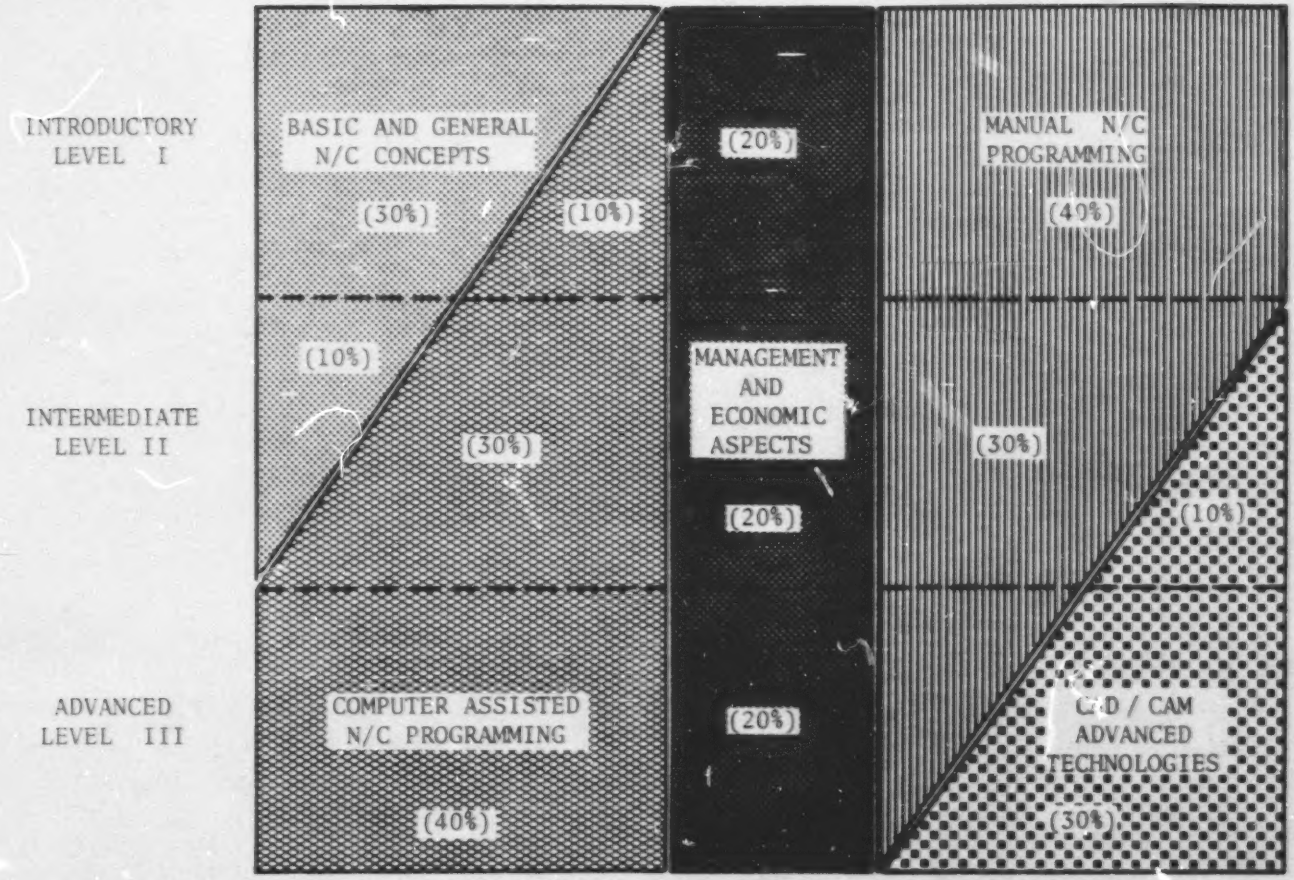
(4) Management and Economic Aspects of N/C

(5) CAD/CAM Advanced Technologies

The overall distribution of content material among these five areas for all three levels should be the following: 50 to 60 percent of

FIGURE 27

CONCEPTUAL MODEL FOR NC/CAM CURRICULUM



manual and computer programming for N/C, 15 percent for general concepts and advanced technologies respectively, and the remaining 15 to 20 percent for management aspects. This distribution varies, however, depending on the particular level of the program, as indicated in the conceptual model of Figure 27.

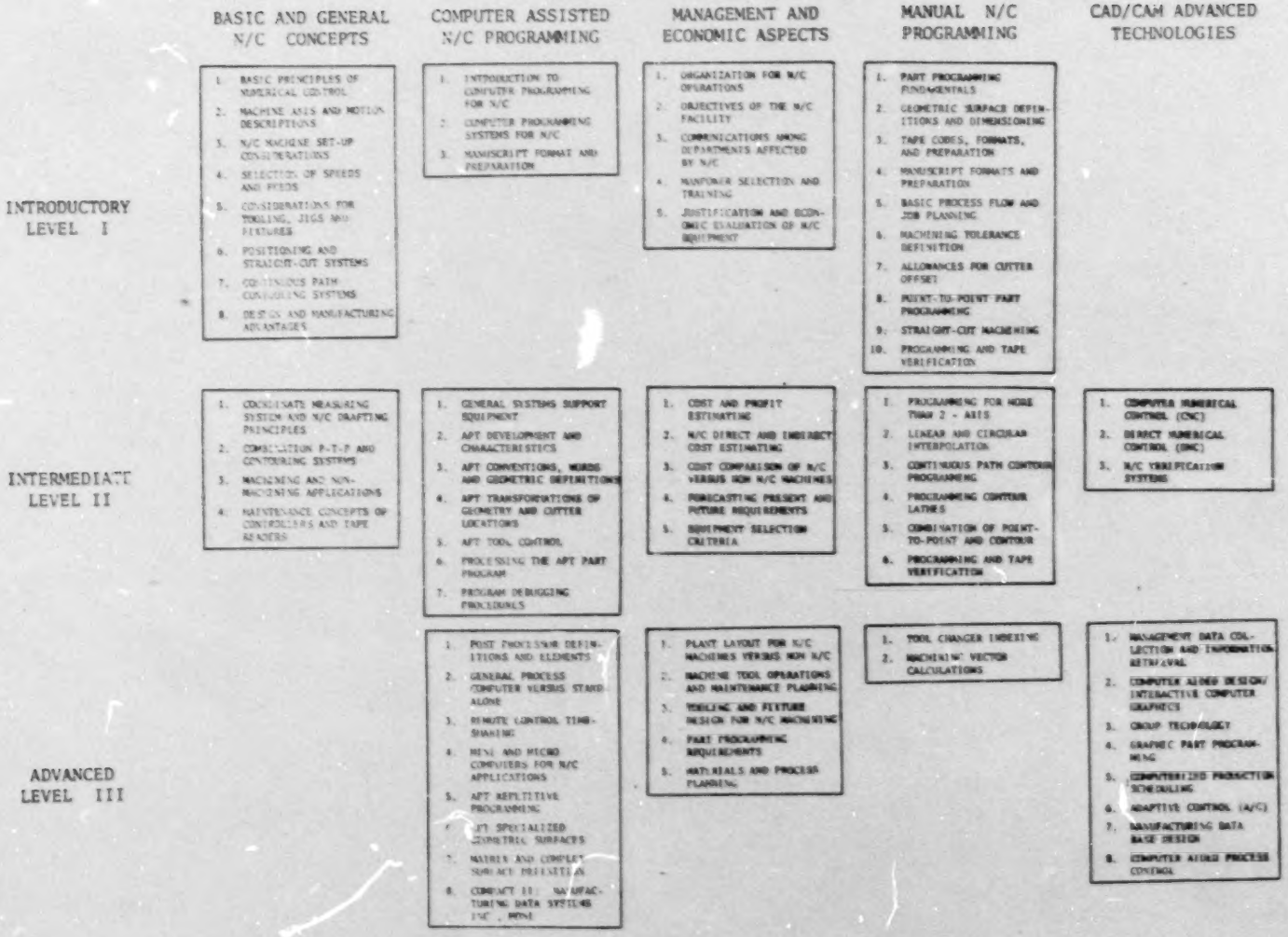
Finally, Figure 28 presents the same curriculum outline in more detail by listing suggested topics for possible inclusion in new curricula at the respective levels and representing elements of priority within the five main areas of NC/CAM as listed above. The introductory Level I should include all main areas with the approximate suggested percentages, with the exception of Advanced Technologies, assuring a more realistically balanced program. The main emphasis of such a program structure is placed on a combination of general N/C concepts, manual programming, introduction to computer programming, and a substantial amount of management related elements.

At Level II, the proportion and emphasis should be changed gradually from manual programming to computer assisted programming. This should also be accompanied by a marked reduction of general concepts in favor of an introduction to advanced technologies of computer aided design and manufacturing.

The same trend should continue through Level II where basic and general concepts are to be phased out and replaced by increased emphasis on advanced technologies. Similarly, manual programming applications

FIGURE 28

SUGGESTED NC/CAM CURRICULUM OUTLINE


BASIC AND GENERAL N/C CONCEPTS
COMPUTER ASSISTED N/C PROGRAMMING
MANAGEMENT AND ECONOMIC ASPECTS
MANUAL N/C PROGRAMMING
CAD/CAM ADVANCED TECHNOLOGIES
INTRODUCTORY LEVEL I
1. BASIC PRINCIPLES OF NUMERICAL CONTROL
2. MACHINE AXES AND MOTION DESCRIPTIONS
3. N/C MACHINE SET-UP CONSIDERATIONS
4. SELECTION OF SPEEDS AND FEEDS
5. CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES
6. POSITIONING AND STRAIGHT-CUT SYSTEMS
7. CONTINUOUS PATH CONTOURING SYSTEMS
8. DESIGN AND MANUFACTURING ADVANTAGES
1. INTRODUCTION TO COMPUTER PROGRAMMING FOR N/C
2. COMPUTER PROGRAMMING SYSTEMS FOR N/C
3. MANUSCRIPT FORMAT AND PREPARATION
1. ORGANIZATION FOR N/C OPERATIONS
2. OBJECTIVES OF THE N/C FACILITY
3. COMMUNICATIONS AMONG DEPARTMENTS AFFECTED BY N/C
4. MANPOWER SELECTION AND TRAINING
5. JUSTIFICATION AND ECONOMIC EVALUATION OF N/C EQUIPMENT
1. PART PROGRAMMING FUNDAMENTALS
2. GEOMETRIC SURFACE DEFINITIONS AND DIMENSIONING
3. TAPE CODES, FORMATS, AND PREPARATION
4. MANUSCRIPT FORMATS AND PREPARATION
5. BASIC PROCESS FLOW AND JOB PLANNING
6. MACHINING TOLERANCE DEFINITION
7. ALLOWANCES FOR CUTTER OFFSET
8. POINT-TO-POINT PART PROGRAMMING
9. STRAIGHT-CUT MACHINING
10. PROGRAMMING AND TAPE VERIFICATION
INTERMEDIATE LEVEL II
1. COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES
2. COMBINATION P-T-P AND CONTOURING SYSTEMS
3. MACHINING AND NON-MACHINING APPLICATIONS
4. MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS
1. GENERAL SYSTEMS SUPPORT EQUIPMENT
2. APT DEVELOPMENT AND CHARACTERISTICS
3. APT CONVENTIONS, WORDS AND GEOMETRIC DEFINITIONS
4. APT TRANSFORMATIONS OF GEOMETRY AND CUTTER LOCATIONS
5. APT TOOL CONTROL
6. PROCESSING THE APT PART PROGRAM
7. PROGRAM DEBUGGING PROCEDURES
1. COST AND PROFIT ESTIMATING
2. N/C DIRECT AND INDIRECT COST ESTIMATING
3. COST COMPARISON OF N/C VERSUS NON N/C MACHINES
4. FORECASTING PRESENT AND FUTURE REQUIREMENTS
5. EQUIPMENT SELECTION CRITERIA
1. PROGRAMMING FOR MORE THAN 2 - AXIS
2. LINEAR AND CIRCULAR INTERPOLATION
3. CONTINUOUS PATH CONTOUR PROGRAMMING
4. PROGRAMMING CONTOUR LATHES
5. COMBINATION OF POINT-TO-POINT AND CONTOUR
6. PROGRAMMING AND TAPE VERIFICATION
1. COMPUTER NUMERICAL CONTROL (CNC)
2. DIRECT NUMERICAL CONTROL (DNC)
3. N/C VERIFICATION SYSTEMS
ADVANCED LEVEL III
1. POST PROCESSOR DEFINITIONS AND ELEMENTS
2. GENERAL PROCESS COMPUTER VERSUS STAND ALONE
3. REMOTE CONTROL TIME-SHARING
4. MINI AND MICRO COMPUTERS FOR N/C APPLICATIONS
5. APT REPETITIVE PROGRAMMING
6. APT SPECIALIZED GEOMETRIC SURFACES
7. MATRIX AND COMPLEX SURFACE DEFINITION
8. COMPACT II - MANUFACTURING DATA SYSTEMS INC., MINI
1. PLANT LAYOUT FOR N/C MACHINES VERSUS NON N/C
2. MACHINE TOOL OPERATIONS AND MAINTENANCE PLANNING
3. TOOLING AND FIXTURE DESIGN FOR N/C MACHINING
4. PART PROGRAMMING REQUIREMENTS
5. MATERIALS AND PROCESS PLANNING
1. TOOL CHANGER INDEXING
2. MACHINING VECTOR CALCULATIONS
1. MANAGEMENT DATA COLLECTION AND INFORMATION RETRIEVAL
2. COMPUTER AIDED DESIGN/INTERACTIVE COMPUTER GRAPHICS
3. GROUP TECHNOLOGY
4. GRAPHIC PART PROGRAMMING
5. COMPUTERIZED PRODUCTION SCHEDULING
6. ADAPTIVE CONTROL (A/C)
7. MANUFACTURING DATA BASE DESIGN
8. COMPUTER AIDED PROCESS CONTROL

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are also reduced in order to allow for an expansion of computer programming applications. Significantly, however, a considerable amount of the instructional program at all three levels should be dedicated to elements of management and economic aspects of N/C. These have traditionally been neglected in many educational programs although consistently listed among the priorities by N/C users in industry.

Implications for Industrial Education and Technology Programs

In reviewing the results and findings of this nationwide survey, which focused on the changing requirements of industry in NC/CAM related areas, several implications for educational programs became evident. If the development trends of the first two decades of this new technology continue, further rapid advances in numerical control can be anticipated. These may occur particularly in connection with more sophisticated computer applications for computer integrated manufacturing.

Present and projected needs for N/C personnel, N/C machine tool utilization, and related programming applications, will require an increased effort on the part of educators in industrial education and technology programs to integrate this technology into their curriculum. According to survey respondents from industry, of the various training sources currently existing, educational institutions provided less than ten percent of their N/C personnel. Therefore, it is imperative that students in these programs be introduced to the opportunities offered

by this new technology. This can be effectively accomplished only by making appropriate educational programs in numerical control technology avaialble on a broad basis.

As evidenced in this survey, the number of post-secondary institutions presently offering N/C instruction increased substantially, particularly in the last six years when the number of programs more than doubled. However, the level and subject matter content in the different programs differ considerably, depending on the specific resources and facilities available in the particular institution.

In order to improve the effectiveness of present instructional programs and to facilitate the planning and organization of new programs, it is suggested that curriculum efforts be oriented on the identified requirements and priorities of industry to assure successful employment of individuals that are qualified and prepared for the challenges of this technology.

In conclusion, it is hoped that the curriculum model, as synthesized from this research, will serve as a general guideline and realistic data base for future detailed curriculum development in industrial education and technology programs in the field of numerical control and computer aided manufacturing.

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APPENDIX A

Letter to Institutions of Higher Education to identify present and planned N/C-Programs

TEXAS A&M UNIVERSITY
COLLEGE OF EDUCATION
COLLEGE STATION, TEXAS 77843

Department of
INDUSTRIAL EDUCATION
INDUSTRIAL ARTS EDUCATION
VOCATIONAL INDUSTRIAL EDUCATION
TECHNICAL EDUCATION
N/C Technology Project

September 22, 1975

Dear Sir:

Because of your position of leadership, your professional assistance is needed to complete a research project investigating the nature of educational programs in Numerical Control (N/C) Machine Tool Technology.

If your institution offers instruction in N/C now or anticipates developing any courses in the near future, it would be most helpful if you would return the form below, with the name of the instructor and the department who is involved in teaching in this area. We would also appreciate receiving course outlines or curriculum guides if you are presently offering N/C courses.

Some time this fall, I would like to communicate with the instructor concerning your educational programs in Numerical Control Technology. In order to maintain the statistical integrity of the survey, please return this form in the enclosed postage paid envelope, even though you may not have a N/C program.

Thank you for your cooperation which will assist in updating educational programs in this important industrial field.

Sincerely,

Klaus D. Bauch
Principal Investigator

KDB/slj

Project Director

James L. Boone, Jr., Ph.D.
Head, Industrial Education

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1. ☐ We do offer instruction in N/C Technology. The person responsible for our program is: _____ (Name and Department)

2. ☐ We currently do not offer a N/C program but intend developing one by _____. The curriculum will be developed by: _____ (Name and Department)

3. ☐ We do not have instruction in N/C, nor do we anticipate developing it in the future.

College: _____ Signature: _____

Address: _____ Date: _____

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APPENDIX B

Letters to Members of APT-Education Agreement and Industrial N/C Training and Information Services

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

February 21, 1975

Dear Sir:

In preparing a nationwide survey, we are presently reviewing pertinent technical literature and educational programs in Numerical Control (NC) Technology.

The objectives of this survey are first, to investigate the nature and characteristics of course offerings in this field in departments of industrial education and engineering technology at four year institutions. Secondly, based on the findings of this survey, we will compile data on current NC/CAM/CAD educational programs. This information will be available to all interested educational institutions.

If your institution offers instruction or other educational services in NC, we would appreciate receiving detailed course syllabi, curriculum guides, and other available NC instructional materials of your program.

Thank you for your cooperation which is needed in order to improve and update educational programs in this field of rapidly growing industrial importance.

Sincerely,

Klaus D. Bauch
Principal Investigator

Robert P. Beals, P.E., Ph.D.
Associate Professor
Project Advisor

RPB:kn

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

February 21, 1975

Dear Sir:

In preparing a nationwide survey, we are presently reviewing pertinent technical literature and educational programs in Numerical Control (NC) Technology.

The objectives of this survey are first, to determine the opinions of knowledgeable representatives from industry with regard to manpower training requirements and competencies in NC Technology. Secondly, investigate the nature of educational programs in institutions of higher education and industrial training programs in NC in order to compile data on currently available NC/CAM/CAD instruction. This information will be made available to all interested educational institutions providing reference data for updating of existing programs based on identified industrial needs and requirements.

The NC Guidebook and directory published annually by Modern Machine Shop lists your company under training, educational and information services. If you offer instruction and training in NC we would appreciate receiving detailed program descriptions, course outlines, and other available NC instructional materials.

Thank you for your cooperation which is needed in order to improve and update educational programs in this field of rapidly growing industrial importance.

Sincerely,

Klaus D. Bauch
Principal Investigator

Robert P. Beals, P.E., Ph.D.
Associate Professor
Project Advisor

RPB:kn

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

March 5, 1975

Dear Sir:

In preparing a nationwide survey, we are presently reviewing pertinent technical literature and educational programs in Numerical Control (NC) Technology.

The objectives of this survey are first, to determine the opinion of knowledgeable representatives from industry with regard to manpower training requirements and competencies in NC Technology. Secondly, investigate the nature of educational programs in institutions of higher education and industrial training programs in NC in order to compile data on currently available NC/CAM/CAD instruction. This information will be available to all interested educational institutions and industrial training centers.

If you have guidelines or standards for selection and training of NC personnel (programmers, operators, coordinators, supervisors, and managers) we would appreciate receiving detailed job descriptions, background and experience requirements, and training subject matter and sources.

We would also be very grateful to receive recent survey information concerning the state-of-the-art of NC technology in operational and equipment applications.

Thank you for your cooperation which will provide valuable reference data for updating of educational programs based on realistic industrial needs and personnel requirements.

Sincerely,

Klaus D. Bauch
Principal Investigator

Robert P. Beals, P.E., Ph.D.
Associate Professor
Project Advisor

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

March 10, 1975

Dear Sir:

In preparing a nationwide survey, we are presently reviewing pertinent technical literature and educational programs in Numerical Control (NC) Technology.

The objectives of this survey are first to determine the manpower training needs and competency requirements of N/C personnel as perceived by industry; secondly, to investigate the nature and characteristics of course offerings in this field in departments of industrial education and engineering technology at four year institutions of higher education. Subsequently, based on the findings of this survey, we will compile data on current NC/CAM/CAD educational programs. This information will be available to all interested educational institutions and industrial training centers.

In order to facilitate the compilation of related literature, we would appreciate receiving current reprints, special reports, and surveys concerning the state-of-the-art of NC Technology applications. If available we would like to request copies of articles relating particularly to computer programming for NC and personnel training in this field. Should it be impossible to provide the above materials directly, please send an index (if available) of all materials published recently.

Thank you for your cooperation which will provide valuable reference data for updating of educational programs in NC based on identified industrial needs and personnel requirements.

Sincerely,

Klaus D. Bauch
Principal Investigator

Robert P. Beals, P.E., Ph.D.
Associate Professor
Project Advisor

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APPENDIX C

Jury Invitation and Instrument Validation

Letters

TEXAS A&M UNIVERSITY
COLLEGE OF EDUCATION
COLLEGE STATION, TEXAS 77843

Department of
INDUSTRIAL EDUCATION
INDUSTRIAL ARTS EDUCATION
VOCATIONAL INDUSTRIAL EDUCATION
TECHNICAL EDUCATION
N/C Technology Project

October 3, 1975

Dear Sir:

We are presently conducting a research study to determine specific tasks and competencies required in N/C Numerical Control Technology which will serve as a basis for curriculum development in this important field of modern industry.

In order to accomplish this objective, we are preparing a nationwide survey of postsecondary educational institutions which offer N/C instruction in departments of industrial education, industrial and engineering technology, as well as mechanical technology in technical education. In addition to these institutions a number of selected industries presently using N/C equipment will also be surveyed in order to determine job requirements and appropriate N/C topics to be included in educational programs.

This survey instrument will contain a comprehensive list of suggested N/C topics which educators and industrial N/C users will rate according to the degree of importance and utilization. Before sending the questionnaire to all respondents, however, we are inciting a jury of experts in both education and industry to assist in evaluating its relevancy.

As a professional with extensive practical and academic experience in N/C Technology would you consider reviewing the questionnaire in order to insure the suitability of the topics and the overall validity? We will appreciate very much your professional opinion and comments in this important matter.

Please indicate below if you are able to participate on the jury panel and return the form in the enclosed postage paid envelope. We will then send you a copy of the survey instrument for review.

____ I will serve on a jury panel to review the questionnaire items.

____ I will not be able to participate.

_____ _____
(Signature) (Date)

(Please return in the enclosed prepaid envelope)

Thank you for your consideration in this matter. Your immediate response will be appreciated.

Most sincerely,

Klaus D. Bauch
Assoc. Project Director

James L. Boone, Jr., Ph.D.
Head, Dept. of Industrial Ed.
Project Director

KD/slj

TEXAS A&M UNIVERSITY
COLLEGE OF EDUCATION
COLLEGE STATION, TEXAS 77843

Department of
INDUSTRIAL EDUCATION
INDUSTRIAL ARTS EDUCATION
VOCATIONAL INDUSTRIAL EDUCATION
TECHNICAL EDUCATION
N/C Technology

Telephone 713-845-52

October 21, 1975

Dear Sir:

Thank you for agreeing to serve on the jury of experts to review our survey questionnaire. The purpose of this survey will be to identify specific tasks and topics which should be considered in developing training, and educational programs in NC/CAM Numerical Control and Computer Aided Manufacturing.

The enclosed preliminary draft of our questionnaire consists of a cover sheet requesting general descriptive information concerning the particular institution's teaching faculty N/C background, equipment, and N/C course characteristics. Following is the actual NC/CAM TRAINING TOPIC INVENTORY with specific directions for the respondents. The instructors will be asked to indicate the relative importance of each topic in their educational program. The relative importance of each topic will be rated on a scale from 1 = no importance to 5 = great importance (see enclosed sample page of final form of questionnaire).

The questionnaire items were selected and compiled on the basis of a comprehensive literature search and preliminary survey results from both industry and education. They are not limited to any specific job requirements but rather propose to cover all the various aspects of numerical control technology.

Therefore, it should be emphasized that no single educational course will include all the topics, nor will any one industrial position require knowledge of all areas. However, the great variety of work tasks and requirements of personnel working in NC/CAM related areas necessitates consideration of all relevant educational aspects. It will be the responsibility of the educational institutions with departments of industrial education, industrial and engineering technology, as well as mechanical technology in vocational

technical education to select from the final survey results the most important elements which are appropriate for their particular objectives and levels of educational programs.

In addition to responding to the questionnaire, please feel free to add, change or comment on the overall topic selection.

Thank you again for participating in the review of our survey instrument. It would be most appreciated if you could return the questionnaire in the enclosed prepaid envelope within the next 10 days to enable us to pilot test it as soon as possible.

Most sincerely,

Klaus D. Bauch
Assoc. Project Director

APPENDIX D

List of Industrial and Educational Jurors

LIST OF JURORS

Industrial Organizations

1. Mehlhope, D., Manager
   Manufacturing Research
   Cincinnati Milacron, Inc.
   Cincinnati, Ohio 45209

2. Moorehead, J. A., President
   John A. Moorehead Associates (JAMA)
   N/C Consulting and Training Services
   Lawrence, Kansas 66044

3. Pahde, T. L., President
   Advanced Manufacturing Concepts
   Florissant, Missouri 63031

4. Smith, D., Manager
   N/C Support
   Cameron Iron Works, Inc.
   Houston, Texas 77000

Educational Institutions

1. Biekert, R. G., Coordinator
   Manufacturing Engineering Technology
   College of Engineering Sciences
   Arizona State University
   Tempe, Arizona 85281

2. Garrett, D., Director
   Technical & Industrial Education
   Washtenaw Community College
   Ann Arbor, Michigan 48106

3. Olling, G., Chairman
   College of Engineering & Technology
   Bradley University
   Peoria, Illinois 61625

4. Winters, W., Director
   Mechanical Technology
   Texas State Technical Institute
   Waco, Texas 76705

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APPENDIX E

Preliminary Survey Instruments (Jury's-Form)

Industrial Group (Part I and II)

Educational Group (Part I only)

A STUDY OF NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING NC/CAM

JURY'S - FORM

CONDUCTED IN COOPERATION WITH THE
DIVISION OF POST-SECONDARY
OCCUPATIONAL EDUCATION AND TECHNOLOGY
TEXAS EDUCATION AGENCY

RETURN TO

MR. KLAUS D. BAUCH
DEPT. OF INDUSTRIAL EDUCATION
N/C TECHNOLOGY PROJECT
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

A QUESTIONNAIRE CONCERNING TASKS AND TOPICS FOR EDUCATIONAL TRAINING PROGRAMS IN NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING

DIRECTIONS: Please answer the following questions as accurately as possible, your name and the name of your company may be excluded, since all information will be treated confidentially and only in survey summary form.

Name (optional) and position of respondent: _____

Name (optional) and place of company: _____

1. TYPE OF BUSINESS AND INDUSTRY:
   - ___ Primary metals industry
   - ___ Fabricated metal products
   - ___ Machinery and equipment
   - ___ Electric/electronic machinery and equipment
   - ___ Transportation equipment
   - ___ Chemical, petrochemical
   - ___ Printing, publishing, paper
   - ___ Other (specify)_____

2. TOTAL NUMBER OF EMPLOYEES IN PLANT:
   - ___ 1 - 24
   - ___ 25 - 99
   - ___ 100 - 249
   - ___ 250 - 999
   - ___ 1000 - 4999
   - ___ 5000 or more

3a. NO. OF N/C MACHINE TYPES:
   - ___ Drilling Machines
   - ___ Milling Machines
   - ___ Lathes
   - ___ Machining Center
   - ___ Other_____

3b. NO. OF N/C CONTROL TYPES:
   - ___ Point-to-Point
   - ___ P-T-P/Straight Line
   - ___ Contour
   - ___ Other _____

3c. NO. OF AXIS:
   - ___ 2 - Axis
   - ___ 3 - Axis
   - ___ 4 - Axis
   - ___ 5 or more

4. APPROXIMATE AMOUNT OF EACH PART PROGRAMMING TECHNIQUE USED:(IN PERCENT TIME)
   - ___ Manual Point-To-Point
   - ___ Manual P-T-P & Straight Line
   - ___ Manual Contour
   - ___ Other (specify)_____
   - ___ Computer programming, in-house
   - ___ A P T programming
   - ___ A P T - Subset (specify)_____
   - ___ NON - A P T (specify)_____

5. WHAT ARE THE PRESENT SOURCES FOR TRAINED PERSONNEL FOR NC/CAM?
   - ___ In-house training
   - ___ Equipment manufacturers
   - ___ Control manufacturers
   - ___ Service bureaus
   - ___ Higher education institutions
   - ___ Vocational/Techn. High Schools
   - ___ Junior or Community College
   - ___ Others (specify)_____

6. WHAT ARE YOUR ESTIMATED TRAINING REQUIREMENTS FOR THE NEXT FIVE YEARS?
   - ___ Manual programmers
   - ___ APT or subset computer progr.
   - ___ Non-APT computer programmers
   - ___ Computer Numerical Control (CNC)
   - ___ Direct Numerical Control (DNC)
   - ___ Others (specify)_____

Additional Comments: _____

NC / CAM TRAINING TOPIC INVENTORY

DIRECTIONS: This questionnaire consists of a list of tasks and topics in eight major areas of NC/CAM that may be included in an educational training program. These areas are: (1) General N/C Concepts, (2) Machine Control Systems, (3) Manual Programming, (4) APT Computer Programming, (5) Non-APT Programming Languages, (6) CAD/CAM, Computer Aided Design / Computer Aided Manufacturing, (7) Economic Aspects, (8) Management Aspects.

Please express your opinion regarding the relevancy and validity of the following N/C topics for educational training programs by checking [Yes] if the item should be included in the final survey questionnaire and [No] if it should be deleted.

AREA (1) GENERAL N/C CONCEPTS	[Yes]	[No]
1. BASIC DEFINITION OF N/C	[ ]	[ ]
2. HISTORY AND DEVELOPMENT OF N/C	[ ]	[ ]
3. DESIGN AND MANUFACTURING ADVANTAGES	[ ]	[ ]
4. PRINCIPAL TYPES OF SYSTEMS	[ ]	[ ]
5. MACHINING AND NON-MACHINING APPLICATIONS	[ ]	[ ]
6. COORDINATE MEASURING SYSTEMS	[ ]	[ ]
7. CLASSIFICATION OF N/C CONTROL SYSTEMS	[ ]	[ ]
8. ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS	[ ]	[ ]
9. CONSIDERATIONS FOR TOOLING, JIGS & FIXTURES	[ ]	[ ]
10. GEOMETRIC DEFINITIONS	[ ]	[ ]
11. MACHINE AXIS AND MOTION DESCRIPTIONS	[ ]	[ ]
12. DECIMAL VS. BINARY NUMBER SYSTEMS	[ ]	[ ]
13. MATHEMATICAL SURFACE DEFINITIONS	[ ]	[ ]
14. LINEAR AND CIRCULAR INTERPOLATION	[ ]	[ ]
15. MACHINING VECTOR CALCULATION	[ ]	[ ]
16. SELECTION OF SPEEDS AND FEEDS	[ ]	[ ]
17. BASIC PRINCIPLES OF N/C CONTROL SYSTEMS	[ ]	[ ]
18. PART PROGRAMMING FUNDAMENTALS	[ ]	[ ]
19. INTRODUCTION TO TAPE CODES & FORMATS	[ ]	[ ]

		[Yes]	[No]
20.	INTRODUCTION TO COMPUTER PROGRAMMING	[ ]	[ ]
21.	N/C SET-UP CONSIDERATIONS	[ ]	[ ]

Additional topics:

AREA (2) MACHINE CONTROL SYSTEMS

22.	MACHINE CONTROL LOOP	[ ]	[ ]
23.	PERFORATED TAPE READERS	[ ]	[ ]
24.	ELECTRONIC AND INTEGRATED CIRCUITRY	[ ]	[ ]
25.	ACTUATORS, AND SERVOS, TRANSDUCERS	[ ]	[ ]
26.	POINT-TO-POINT POSITIONING SYSTEMS	[ ]	[ ]
27.	POSITIONING & STRAIGHT-CUT SYSTEMS	[ ]	[ ]
28.	CONTINUOUS PATH CONTOURING SYSTEMS	[ ]	[ ]
29.	COMBINATION P-T-P CONTOURING SYSTEMS	[ ]	[ ]
30.	N/C DATA PROCESSING EQUIPMENT	[ ]	[ ]
31.	GENERAL SYSTEMS SUPPORT EQUIPMENT	[ ]	[ ]
32.	TABULATING & PUNCHING EQUIPMENT	[ ]	[ ]
33.	INTERNALLY PROGRAMMED SYSTEMS	[ ]	[ ]
34.	OFF-LINE INTERPOLATOR SYSTEMS	[ ]	[ ]
35.	DIGITAL MAGNETIC TAPE SYSTEMS	[ ]	[ ]
36.	DIRECT NUMERICAL CONTROL SYSTEMS (DNC)	[ ]	[ ]
37.	COMPUTER NUMERICAL CONTROL SYSTEMS (CNC)	[ ]	[ ]
38.	ADAPTIVE NUMERICAL CONTROL SYSTEMS (A/C)	[ ]	[ ]
39.	FEED BACK CONTROL SYSTEMS	[ ]	[ ]
40.	REMOTE CONTROL DATA COMMUNICATION	[ ]	[ ]
41.	GENERAL PROCESS CPU VS. STAND-ALONE	[ ]	[ ]

Additional topics:

		[Yes]	[No]
	AREA (3) MANUAL PROGRAMMING		
42.	TYPES OF DIMENSIONING SYSTEMS	[ ]	[ ]
43.	MEASUREMENT SYSTEM	[ ]	[ ]
44.	FORMAT TYPES AND ZERO DEFINITION	[ ]	[ ]
45.	MANUSCRIPT FORMS	[ ]	[ ]
46.	MANUSCRIPT & TAPE PREPARATION	[ ]	[ ]
47.	SPEED & FEED SELECTION	[ ]	[ ]
48.	MACHINING TOLERANCE DEFINITION	[ ]	[ ]
49.	ALLOWANCES FOR CUTTER OFFSET	[ ]	[ ]
50.	PROGRAMMING & TAPE VERIFICATION	[ ]	[ ]
51.	POINT-TO-POINT PART PROGRAMMING	[ ]	[ ]
52.	STRAIGHT-CUT MACHINING	[ ]	[ ]
53.	PROGRAMMING FOR MORE THAN 2-AXIS	[ ]	[ ]
54.	TOOL CHANGER INDEXING	[ ]	[ ]
55.	CONTINUOUS PATH CONTOUR PROGRAMMING	[ ]	[ ]
56.	CIRCULAR MOTIONS CIRCULAR INTERPOLATION	[ ]	[ ]
57.	PROGRAMMING CONTOUR LATHES	[ ]	[ ]
58.	COMBINATION OF POINT-TO-POINT AND CONTOUR	[ ]	[ ]
59.	TAPE VERIFICATION	[ ]	[ ]
	Additional topics:		
	AREA (4) APT COMPUTER PROGRAMMING		
60.	INTRODUCTION TO COMPUTERS	[ ]	[ ]
61.	INPUT/OUTPUT EQUIPMENT	[ ]	[ ]
62.	PROGRAMMING SYSTEMS	[ ]	[ ]
63.	APT DEVELOPMENT	[ ]	[ ]

		[Yes]	[No]
64.	BASIC GEOMETRIC DEFINITION FOR APT	[ ]	[ ]
65.	FORMAT (FIXED SEQUENTIAL, TAB SEQUENTIAL, VARIABLE BLOCK, ETC.)	[ ]	[ ]
66.	APT CONVENTIONS AND GEOMETRIC DEFINITIONS	[ ]	[ ]
67.	APT WORDS	[ ]	[ ]
68.	APT MANUSCRIPT PREPARATION	[ ]	[ ]
69.	POST PROCESSOR DEFINITIONS AND ELEMENTS	[ ]	[ ]
70.	PROCESSING THE APT PART PROGRAM	[ ]	[ ]
71.	APT TOOL CONTROL	[ ]	[ ]
72.	ADDITIONAL APT CONCEPTS (LOOPING, MACRO)	[ ]	[ ]
73.	APT REPETITIVE PROGRAMMING	[ ]	[ ]
74.	ADVANCED APT FEATURES (CANON, PRINT, DNT-CUT, ETC.)	[ ]	[ ]
75.	MATRIX & COMPLEX SURFACE DEFINITION	[ ]	[ ]
76.	APT TRANSFORMATION OF GEOMETRY & CUTTER LOCATION	[ ]	[ ]
77.	APT SPECIALIZED GEOMETRIC SURFACES DLCONIC, CCONIC, RLDSRF, ETC.	[ ]	[ ]
78.	4 and 5 AXIS APT PROGRAMMING	[ ]	[ ]
79.	APT POST PROCESSOR	[ ]	[ ]

Additional topics:

AREA (5) NON-APT PROGRAMMING LANGUAGES

80.	ADAPT: ADAPTATION OF APT	[ ]	[ ]
81.	UNIAPT: UNITED COMPUTING CORPORATION APT	[ ]	[ ]
82.	MOD-APT:MODIFIED APT	[ ]	[ ]
83.	EXAPT: EXTENDED SUBSET OF APT	[ ]	[ ]
84.	DATAPREP: DATA PREPARATION BY DATA GENERAL CORP.	[ ]	[ ]
85.	COMPACT II: BY MANUFACTURING DATA SYSTEMS INC. MDSI	[ ]	[ ]
86.	AUTOSPOT: AUTOMATIC SYSTEM FOR POSITIONING TOOLS	[ ]	[ ]

		[Yes]	[No]
87.	NEL-NUMERICAL CONTROL PROCESSORS	[ ]	[ ]
88.	SYMPAC: SYMBOLIC PROGRAM FOR AUTOMATIC CONTROLS	[ ]	[ ]
89.	SPLIT: SUNDSTRAND PROCESSING LANGUAGE INTERNALLY TRANSLATED	[ ]	[ ]
90.	AUTOPROMPT: AUTOMATIC PROGRAMMED TOOLS	[ ]	[ ]
91.	AUTOMAP: AUTOMATIC MACHINING PROGRAM .	[ ]	[ ]
92.	SNAP: SIMPLIFIED NUMERICAL AUTOMATIC PROGRAMMER	[ ]	[ ]
93.	PRONTO: PROGRAM FOR NUMERICAL TOOLS	[ ]	[ ]
94.	AUTOPROPS: AUTOMATIC PROGRAM FOR POSITIONING SYSTEM	[ ]	[ ]
95.	CAMP II: COMPILER FOR AUTOMATIC MACHINE PROGRAMMING	[ ]	[ ]
96.	CAMP 5: COMPILER FOR AUTOMATIC N/C PROGRAMMING	[ ]	[ ]

Additional topics:

AREA (6) CAD - COMPUTER AIDED DESIGN
CAM - COMPUTER AIDED MANUFACTURING

97.	EDP & DIGITAL SYSTEM'S LOGICAL CONCEPTS	[ ]	[ ]
98.	N/C VERIFICATION SYSTEMS	[ ]	[ ]
99.	GRAPHIC PART PROGRAMMING	[ ]	[ ]
100.	INTERACTIVE GRAPHICS CAD	[ ]	[ ]
101.	AUTOMATED DRAWING GENERATION	[ ]	[ ]
102.	MANAGEMENT DATA COLLECTION	[ ]	[ ]
103.	MACHINE OPERATING COMPENSATION	[ ]	[ ]
104.	MANUFACTURING DATA BASE DESIGN	[ ]	[ ]
105.	COMPUTERIZED MATERIAL HANDLING .	[ ]	[ ]
106.	COMPUTER CONTROLLED TRANSFER LINE	[ ]	[ ]
107.	COMPUTER CONTROLLED ASSEMBLY LINE OPERATIONS	[ ]	[ ]
108.	IN-PROCESS INSPECTION	[ ]	[ ]
109.	COMPUTERIZED SCHEDULING	[ ]	[ ]

		[Yes]	[No]
110.	INFORMATION RETRIEVAL	[ ]	[ ]
111.	GROUP TECHNOLOGY	[ ]	[ ]
112.	DIRECT NUMERICAL CONTROL (DNC)	[ ]	[ ]
113.	COMPUTER NUMERICAL CONTROL (CNC)	[ ]	[ ]
114.	ADAPTIVE CONTROL (A/C)	[ ]	[ ]
115.	COMPUTER AIDED PROCESS CONTROL	[ ]	[ ]
116.	TIME SHARING UNITS AND COMPUTER SOFTWARE	[ ]	[ ]

Additional topics:

AREA (7) ECONOMIC ASPECTS

117.	MARKETING FUNCTION	[ ]	[ ]
118.	FORECASTING PRESENT & FUTURE REQUIREMENTS	[ ]	[ ]
119.	BREAKEVEN CALCULATIONS	[ ]	[ ]
120.	PROFIT ESTIMATING	[ ]	[ ]
121.	COST ESTIMATING	[ ]	[ ]
122.	COST COMPARISON OF NUMERICAL CONTROL VS. CONVENTIONAL MACHINE CONTROL	[ ]	[ ]
123.	EQUIPMENT SELECTION CRITERIA	[ ]	[ ]
124.	ECONOMIC EVALUATION	[ ]	[ ]
125.	JUSTIFICATION OF N/C EQUIPMENT	[ ]	[ ]
126.	DEPRECIATION & TAXES	[ ]	[ ]
127.	DETERMINATION OF ACQUISATION COST	[ ]	[ ]
128.	ESTABLISHING DIRECT BENEFITS	[ ]	[ ]
129.	ANALYSIS OF INDIRECT BENEFITS	[ ]	[ ]
130.	N/C DIRECT COST ESTIMATING	[ ]	[ ]
131.	N/C INDIRECT COST ESTIMATING	[ ]	[ ]
132.	PART PROGRAMMING	[ ]	[ ]

		[Yes]	[No]
133.	RETROFITTING	[ ]	[ ]
134.	SMALL BUSINESS CONSIDERATIONS	[ ]	[ ]

Additional topics:

AREA (8) MANAGEMENT ASPECTS

135.	OBJECTIVES OF THE N/C FACILITY	[ ]	[ ]
136.	ORGANIZATION FOR N/C OPERATIONS	[ ]	[ ]
137.	N/C PLANT LAYOUT	[ ]	[ ]
138.	PLANNING FOR CONVENTIONAL MACHINE TOOLS	[ ]	[ ]
139.	PROCESS PLANNING FOR N/C	[ ]	[ ]
140.	PRODUCT DESIGN & DEVELOPMENT	[ ]	[ ]
141.	TOOLING & FIXTURE DESIGN	[ ]	[ ]
142.	MATERIALS PLANNING	[ ]	[ ]
143.	MACHINE TOOL OPERATION	[ ]	[ ]
144.	DATA PROCESSING	[ ]	[ ]
145.	SETTING STANDARDS & METHODS	[ ]	[ ]
146.	TAPE PREPARATION & VERIFICATION	[ ]	[ ]
147.	QUALITY ASSURANCE & CONTROL	[ ]	[ ]
148.	PRODUCTION SCHEDULING	[ ]	[ ]
149.	COST ESTIMATING	[ ]	[ ]
150.	MANPOWER SELECTION	[ ]	[ ]
151.	MANPOWER TRAINING	[ ]	[ ]
152.	COMMUNICATIONS, CO-ORDINATIONS	[ ]	[ ]
153.	RELATIONSHIPS, CONTROLS & RESPONSIBILITIES	[ ]	[ ]
154.	RETROFITTING OF CONVENTIONAL MACHINE TOOLS	[ ]	[ ]
155.	MAINTENANCE PLANNING CONSIDERATIONS	[ ]	[ ]

Additional topics:

A QUESTIONNAIRE CONCERNING TASKS AND TOPICS
FOR EDUCATIONAL TRAINING PROGRAMS IN
NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING

DIRECTIONS: Please answer the following questions as accurately as possible, your name and the name of your company may be excluded, since all information will be treated confidentially and only in survey summary form.

Name (optional) and Position of Faculty Member: _____

Name (optional) and Place of Institution: _____

1. NUMBER OF FACULTY IN THE DEPARTMENT:
   ___ Full Time ___ Total Number

2. NUMBER OF STUDENTS IN THE DEPARTMENT:
   ___ Majors ___ Total Enrollment

3. MAIN TEACHING AREA OF RESPONDENT (NUMBER OF YEARS):
   ___ Industrial Arts ___ Industrial Technology
   ___ Vocational Education ___ Engineering Technology

4. COMPETENCY IN N/C ACQUIRED THROUGH (NUMBER OF YEARS):
   ___ Formal Education ___ Industrial Experience
   ___ Teaching Experience ___ Self-taught

5a. NO. OF N/C MACHINE TYPES:
   ___ Drilling Machines
   ___ Milling Machines
   ___ Lathes
   ___ Machining Center
   ___ Others_____

5b. NO. OF N/C CONTROL TYPES:
   ___ Point-to-Point
   ___ P-T-P/Straight Line
   ___ Contour
   ___ Other_____

3c. NO. OF AXIS:
   ___ 2-Axis
   ___ 3-Axis
   ___ 4-Axis
   ___ 5 or more
   _____

6. APPROXIMATE AMOUNT OF EACH PART PROGRAMMING TECHNIQUE USED (IN PERCENT TIME):
   ___ Manual Point-To-Point ___ Computer programming, in-house
   ___ Manual P-T-P & Straight Line ___ A P T programming
   ___ Manual Contour ___ A P T - Subset (specify)_____
   ___ Other (specify)_____ ___ NON - A P T (specify)_____

7. LEVEL OF COURSES OFFERED IN N/C:
   ___ Freshman ___ Junior
   ___ Sophomore ___ Senior

8. DURATION AND SIZE PER COURSE:
   ___ Number of N/C Courses ___ Students per Course
   ___ Lecture / Lab. Hours per Semester Course ___ Students per Academic Year

Additional Comments: _____

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APPENDIX F

Letters to Survey Participants

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

January 26, 1976

Dear Sir:

The Numerical Control Society was kind enough to permit us to contact its membership for the purpose of requesting your professional assistance in a nationwide research study to determine tasks and topics for educational training programs in the increasingly important field of Numerical Control-Computer Aided Manufacturing NC/CAM.

This study focuses (1) on the changing needs and requirements of industry applying this sophisticated technology and (2) on the training of individuals preparing for employment in NC/CAM related fields. As a member of the NC Society and a knowledgeable professional of this technology, you are in a unique position to assist us in identifying the essential tasks and knowledge required for successful application in industry.

YOUR RESPONSE TO THIS QUESTIONNAIRE IS EXTREMELY VALUABLE since it will contribute to the preparation of better qualified technical personnel critical to each company's efforts to increase productivity.

The enclosed questionnaire consists of two parts, the first part serves to determine the degree to which your company is involved in NC. This information will be treated confidentially and does not require your company's name since all data will be used in summary form only. The second part is the actual list of NC/CAM TRAINING TOPICS. It is divided into 5 main areas which solicit your professional opinion as to the relative importance of each topic for NC training programs. Since it is imperative that we receive a high percentage of returns, please return the questionnaire in any case, even though you may not have answered all questions.

Your early response, using the enclosed postage paid envelope, will be appreciated. This will allow us to make the survey results available to all respondents without delay.

Sincerely,

Robert P. Beals, P.E.
Associate Professor, Ind. Eng.
Technical Consultant

Klaus D. Bauch
Associate Project Director

KDB:jt
Enclosures

TEXAS A&M UNIVERSITY
COLLEGE OF ENGINEERING
COLLEGE STATION TEXAS 77843

DEPARTMENT OF INDUSTRIAL ENGINEERING

January 26, 1976

Dear Sir:

The office of Computer Aided Manufacturing-International (CAM-I, Inc.) was kind enough to permit us to contact its membership for the purpose of requesting your professional assistance in a nationwide research study to determine tasks and topics for educational training programs in the increasingly important field of Numerical Control-Computer Aided Manufacturing NC/CAM.

This study focuses (1) on the changing needs and requirements of industry applying this sophisticated technology and (2) on the training of individuals preparing for employment in NC/CAM related fields. As a member of the CAM-I, Inc. and a knowledgeable professional of this technology, you are in a unique position to assist us in identifying the essential tasks and knowledge required for successful application in industry.

YOUR RESPONSE TO THIS QUESTIONNAIRE IS EXTREMELY VALUABLE since it will contribute to the preparation of better qualified technical personnel critical to each company's efforts to increase productivity.

The enclosed questionnaire consists of two parts, the first part serves to determine the degree to which your company is involved in NC. This information will be treated confidentially and does not require your company's name since all data will be used in summary form only. The second part is the actual list of NC/CAM TRAINING TOPICS. It is divided into 5 main areas which solicit your professional opinion as to the relative importance of each topic for NC training programs. Since it is imperative that we receive a high percentage of returns, please return the questionnaire in any case, even though you may not have answered all questions.

Your early response, using the enclosed postage paid envelope, will be appreciated. This will allow us to make the survey results available to all respondents without delay.

Sincerely,

Robert P. Beals, P.E.
Associate Professor, Ind. Eng.
Technical Consultant

Klaus D. Bauch
Associate Project Director

KDB:jt
Enclosures

TEXAS A&M UNIVERSITY

DEPARTMENT OF ENGINEERING TECHNOLOGY

COLLEGE STATION, TEXAS 77843
(713) 845-4951

B.S. DEGREE OPTIONS
Engineering Technology
Industrial Distribution
Industrial Technology

M.S. DEGREE OPTIONS
Industrial Technology

January 26, 1976

Dear Sir:

Through a preliminary survey sent to all ECPD accredited schools offering 4 year technology programs, we identified those departments which offer instruction in Numerical Control (N/C) Machine Tool Technology or are planning to develop new courses in N/C in the near future.

Since your department head identified you as the person responsible for your present program or the development of future curriculum in this area, we request your professional assistance in a nationwide survey of educational institutions and N/C users in industry. The purpose of this survey is to determine tasks and topics for educational training programs in the increasingly important field of Numerical Control-Computer Aided Manufacturing NC/CAM.

The enclosed questionnaire consists first of one page of descriptive information concerning your present instructional program in N/C, which will be treated confidentially and reported in summary form only. The second part is the actual list of NC/CAM TRAINING TOPICS. It is divided into 5 main areas which solicit your professional opinion as to the relative importance of each topic in your educational program. Please answer all items if possible, however, if you choose not to respond to a certain area, return the questionnaire in any case.
YOUR RESPONSE TO THIS QUESTIONNAIRE IS EXTREMELY VALUABLE.

It will be appreciated very much if you respond at your earliest convenience using the enclosed postage paid envelope so that we may summarize the survey results and make them available to all respondents.

Sincerely,

Jon F. Botsford, D.Ed.
Assistant Prof. Eng. Techn.
Technical Consultant

Klaus D. Bauch
Associate Project Director

KDB:jt
Enclosure

TEXAS A&M UNIVERSITY
COLLEGE OF EDUCATION
COLLEGE STATION, TEXAS 77843

Department of
INDUSTRIAL EDUCATION
INDUSTRIAL ARTS EDUCATION
VOCATIONAL INDUSTRIAL EDUCATION
TECHNICAL EDUCATION

Telephone 713-8

N/C Technology Project

January 26, 1976

Dear Sir:

Through a preliminary survey of all Industrial Teacher Education Institutions, we identified those departments which offer instruction in Numerical Control (N/C) Machine Tool Technology or are planning new courses in the near future.

Since your department head identified you as the person responsible for your present program or the development of future curriculum in this area, we solicit your professional assistance in a nationwide survey of educational institutions and N/C users in industry. The purpose of this survey is to determine tasks and topics for educational training programs in the increasingly important field of Numerical Control-Computer Aided Manufacturing NC/CAM.

The enclosed questionnaire consists of two parts, the first part concerns information about your present instructional program in N/C, which will be treated confidentially and reported in summary form only. The second part is the actual list of NC/CAM TRAINING TOPICS. It is divided into 5 main areas which solicit your professional opinion as to the relative importance of each topic in your educational program. Please answer all items if possible, however, if you choose not to respond to a certain area, return the questionnaire in any case.
YOUR RESPONSE TO THIS QUESTIONNAIRE IS XTREMELY VALUABLE.

It will be appreciated very much if you respond at your earliest convenience using the enclosed postage paid envelope so that we may summarize the survey results and make them available to all respondents.

Sincerely,

James L. Soone, Jr.
Head, Industrial Education
Project Director

Klaus D. Bauch
Associate Project Director

KDB:jt
Enclosures

TEXAS A&M UNIVERSITY
COLLEGE OF EDUCATION
COLLEGE STATION, TEXAS 77843

Department of
INDUSTRIAL EDUCATION
INDUSTRIAL ARTS EDUCATION
VOCATIONAL INDUSTRIAL EDUCATION
TECHNICAL EDUCATION

Telephone 713-8

N/C Technology

January 26, 1976

Dear Sir:

Through a preliminary survey among selected post-secondary institutions offering 2 year occupational-technical programs, we identified those departments which offer instruction in Numerical Control (N/C) Machine Tool Technology or are planning to develop new courses in N/C in the near future.

Would you or the instructor in your department responsible for your present program in this area please respond to a brief questionnaire? The purpose of this survey is to determine tasks and topics for educational training programs in this increasingly important field.

The enclosed questionnaire consists of two parts, the first part concerning information about your present instructional program in N/C, which will be treated confidentially and reported in summary form only. The second part is the actual list of NC/CAM TRAINING TOPICS. It is divided into 5 main areas which solicit your professional opinion as to the relative importance of each topic in your educational program. Please answer all items if possible, however, if you choose not to respond to a certain area, return the questionnaire in any case.
YOUR RESPONSE TO THIS QUESTIONNAIRE IS EXTREMELY VALUABLE.

It will be appreciated very much if you respond at your earliest convenience using the enclosed postage paid envelope so that we may summarize the survey results and make them available to all respondents.

Sincerely,

James L. Boone, Jr.
Head, Industrial Education
Project Director

Klaus D. Bauch
Associate Project Director

KDB:jt
Enclosures

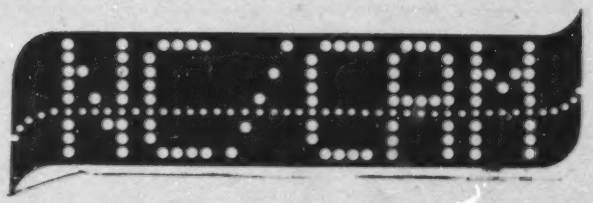
BEST COPY AVAILABLE

APPENDIX G

Final Survey Instruments

Industrial Group (Part I and II)

Educational Group (Part I only)



A STUDY OF NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING

CONDUCTED IN COOPERATION WITH THE
DIVISION OF POST-SECONDARY
OCCUPATIONAL EDUCATION AND TECHNOLOGY
TEXAS EDUCATION AGENCY

RETURN TO

MR. KLAUS D. BAUCH
DEPT. OF INDUSTRIAL EDUCATION
N/C TECHNOLOGY PROJECT
TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843

A QUESTIONNAIRE CONCERNING TASKS AND TOPICS FOR EDUCATIONAL TRAINING PROGRAMS IN NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING

DIRECTIONS: *Please answer the following questions as accurately as possible. All information will be treated confidentially and only in survey summary form.*

1. NAME AND POSITION OF RESPONDENT: _____

2. NAME AND PLACE OF COMPANY: _____

3a. NUMBER OF EMPLOYEES IN PLANT: (CHECK)

___ 1 - 24
___ 25 - 99
___ 100 - 249
___ 250 - 499
___ 500 - 999
___ 1000 - 2499
___ 2500 - 4999
___ 5000 or more

3b. NUMBER OF N/C-PERSONNEL IN PLANT:

___ N/C Machine Operators
___ N/C Maintenance Personnel
___ N/C Supervisors/Coordinators
___ N/C Programmers

4a. MAIN WORK AREA OF RESPONDENT: (YEARS)

___ Design
___ Production
___ Programming
___ Maintenance
___ Tooling / Set-up
___ Sales / Service
___ Research/Develop.
___ Other _____

4b. COMPETENCY IN N/C ACQUIRED THROUGH:

___ Formal Education (Years)
___ Correspondence Courses (Years)
___ N/C Work Experience (Years)
___ Self-taught (Years)

5a. NUMBER OF N/C MACHINES:

___ Drilling Machines
___ Milling Machines
___ Lathes
___ Machining Centers
___ Other_____

5b. NUMBER OF N/C CONTROLS:

___ Point-to-Point
___ P-T-P/Straight Line
___ Contour
___ Minicomputer
___ Other_____

5c. NUMBER OF AXIS:

___ 2 - Axis
___ 3 - Axis
___ 4 - Axis
___ 5 or more
___ Other_____

6. WHAT IS THE APPROXIMATE PERCENT TIME OF EACH PART PROGRAMMING TECHNIQUE USED?

___ Manual Point-to-Point
___ Manual P-T-P & Straight Line
___ Manual Contour
___ Computer, in-house language
___ APT programming
___ Other languages (list)_____

7. WHAT IS THE APPROXIMATE PERCENTAGE OF EACH SOURCE FOR TRAINING OF N/C PERSONNEL?

___ In-house training
___ Equipment manufacturers
___ Control manufacturers
___ Service bureaus
___ Higher education institutions
___ Vocational/Techn. High Schools
___ Junior or Community College
___ Others (specify)_____

8. WHAT IS THE ESTIMATED NUMBER OF NEW PERSONNEL FOR THE NEXT FIVE YEARS?

___ Manual programmers
___ APT computer programmer
___ Other computer programmers (specify)_____
___ N/C Machine Operators
___ N/C Maintenance Personnel
___ N/C Supervisors/Coordinators
___ Others (specify)_____

Do you use a time-share service company (__Check) or your own computer? (__Check)
What is your main line of business and/or industry?_____
How many years has your company used N/C machine tools? (__Years)
How many N/C machine tools and what type are you planning to purchase?_____ (No./Type)

Additional Comments:_____

NC / CAM TRAINING TOPIC INVENTORY

DIRECTIONS: *This questionnaire consists of a list of tasks and topics in five major areas of NC/CAM that may be included in an educational training program. These areas are: (1) Basic N / C Concepts, (2) Manual Programming, (3) Computer Assisted Programming, (4) Management Aspects, (5) Advanced Technologies.*

Please indicate your opinion as to the relative importance that each topic should have in educational programs based on the requirements of your type of business and/or industry. Place an X in one of the five boxes provided as illustrated in the example below.

RELATIVE VALUE OF IMPORTANCE:

5 - GREAT IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
3 - MODERATE IMPORTANCE
2 - LIMITED IMPORTANCE
1 - NO IMPORTANCE

AREA 1 BASIC N/C CONCEPTS	IMPORTANCE				
	5 GREAT	4 SUBSTANTIAL	3 MODERATE	2 LIMITED	1 NO
EXAMPLE: PROGRAMMING 4 - AXIS CONTOUR MILLS				X	
1. HISTORY AND DEVELOPMENT OF NUMERICAL CONTROL					
2. BASIC PRINCIPLES OF NUMERICAL CONTROL					
3. COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES					
4. CLASSIFICATION OF N/C CONTROL SYSTEMS					
5. DESIGN AND MANUFACTURING ADVANTAGES					
6. MACHINING AND NON-MACHINING APPLICATIONS					
7. MACHINE AXIS AND MOTION DESCRIPTIONS					
8. ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS, EIA					
9. DECIMAL VERSUS BINARY NUMBER SYSTEMS					
10. SELECTION OF SPEEDS AND FEEDS					
11. CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES					
12. N/C MACHINE SET-UP CONSIDERATIONS					
13. MACHINE CONTROL LOOP AND FEEDBACK					
14. POINT-TO-POINT POSITIONING SYSTEMS					
15. POSITIONING AND STRAIGHT-CUT SYSTEMS					
16. CONTINUOUS PATH CONTOURING SYSTEMS					
17. COMBINATION P-T-P AND CONTOURING SYSTEMS					
18. MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS					

RELATIVE VALUE OF IMPORTANCE:

5 - GREAT IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
3 - MODERATE IMPORTANCE
2 - LIMITED IMPORTANCE
1 - NO IMPORTANCE

		IMPORTANCE				
		5	4	3	2	1
		GREAT	SUBSTANTIAL	MODERATE	LIMITED	NO
	AREA 2 MANUAL PROGRAMMING					
19.	BASIC PROCESS FLOW AND JOB PLANNING					
20.	PART PROGRAMMING FUNDAMENTALS					
21.	GEOMETRIC SURFACE DEFINITIONS AND DIMENSIONING					
22.	LINEAR AND CIRCULAR INTERPOLATION					
23.	MANUSCRIPT FORMATS AND PREPARATION					
24.	TAPE CODES, FORMATS, AND PREPARATION					
25.	MACHINING VECTOR CALCULATIONS					
26.	MACHINING TOLERANCE DEFINITION					
27.	ALLOWANCES FOR CUTTER OFFSET					
28.	PROGRAMMING AND TAPE VERIFICATION					
29.	POINT-TO-POINT PART PROGRAMMING					
30.	STRAIGHT-CUT MACHINING					
31.	PROGRAMMING FOR MORE THAN 2 - AXIS					
32.	TOOL CHANGER INDEXING					
33.	CONTINUOUS PATH CONTOUR PROGRAMMING					
34.	PROGRAMMING CONTOUR LATHES					
35.	COMBINATION OF POINT-TO-POINT AND CONTOUR					
36.	TAPE VERIFICATION					
	AREA 3 COMPUTER ASSISTED PROGRAMMING					
37.	INTRODUCTION TO COMPUTER PROGRAMMING FOR N/C					
38.	PROGRAMMING SYSTEMS FOR N/C					
39.	GENERAL SYSTEMS SUPPORT EQUIPMENT					
40.	GENERAL PROCESS COMPUTER VERSUS STAND-ALONE					
41.	REMOTE CONTROL TIMESHARING					
42.	MINI AND MICRO COMPUTERS FOR N/C APPLICATIONS					
43.	APT DEVELOPMENT AND CHARACTERISTICS					
44.	MANUSCRIPT FORMAT AND PREPARATION					
	Additional topics:					

RELATIVE VALUE OF IMPORTANCE:

5 - GREAT IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
3 - MODERATE IMPORTANCE
2 - LIMITED IMPORTANCE
1 - NO IMPORTANCE

		IMPORTANCE				
		5	4	3	2	1
		GREAT	SUBSTANTIAL	MODERATE	LIMITED	NO
45.	APT CONVENTIONS, WORDS AND GEOMETRIC DEFINITIONS					
46.	APT TRANSFORMATIONS OF GEOMETRY AND CUTTER LOCATIONS					
47.	APT TOOL CONTROL					
48.	APT REPETITIVE PROGRAMMING					
49.	MATRIX AND COMPLEX SURFACE DEFINITION					
50.	APT SPECIALIZED GEOMETRIC SURFACES					
51.	APT PROGRAMMING FOR 4 AND 5 AXIS					
52.	POST PROCESSOR DEFINITIONS AND ELEMENTS					
53.	PROCESSING THE APT PART PROGRAM					
54.	PROGRAM DEBUGGING PROCEDURES					
55.	ADAPT: ADAPTATION OF APT BY IBM					
56.	UNIAPT: UNITED COMPUTING CORPORATION APT					
57.	COMPACT II: MANUFACTURING DATA SYSTEMS INC., MDSI					
58.	SPLIT: SUNDSTRAND PROCESS. LANG. INTERNALLY TRANSLATED					
59.	ACTION: MANUFACTURING DATA SYSTEMS, INC., MDSI					
60.	NUFORM: A.S. THOMAS, INC.					
	AREA 4 MANAGEMENT ASPECTS					
61.	FORECASTING PRESENT AND FUTURE REQUIREMENTS					
62.	BREAKEVEN CALCULATIONS					
63.	N/C DIRECT AND INDIRECT COST ESTIMATING					
64.	COST AND PROFIT ESTIMATING					
65.	COST COMPARISON OF N/C VERSUS NON N/C MACHINES					
66.	EQUIPMENT SELECTION CRITERIA					
67.	JUSTIFICATION AND ECONOMIC EVALUATION OF N/C EQUIPMENT					
68.	COMMUNICATIONS AMONG DEPARTMENTS AFFECTED BY N/C					
69.	PART PROGRAMMING REQUIREMENTS					
70.	OBJECTIVES OF THE N/C FACILITY					
71.	ORGANIZATION FOR N/C OPERATIONS					
72.	PLANT LAYOUT FOR N/C MACHINES VERSUS NON N/C					
	Additional topics:					

RELATIVE VALUE OF IMPORTANCE:

5 - GREAT IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
3 - MODERATE IMPORTANCE
2 - LIMITED IMPORTANCE
1 - NO IMPORTANCE

		IMPORTANCE				
		5	4	3	2	1
		GREAT	SUBSTANTIAL	MODERATE	LIMITED	NO
73.	MATERIALS AND PROCESS PLANNING					
74.	PRODUCT DESIGN AND DEVELOPMENT					
75.	TOOLING AND FIXTURE DESIGN FOR N/C MACHINING					
76.	MACHINE TOOL OPERATION AND MAINTENANCE PLANNING					
77.	SETTING STANDARDS AND METHODS					
78	QUALITY ASSURANCE AND CONTROL					
79.	PRODUCTION SCHEDULING					
80.	MANPOWER SELECTION AND TRAINING					
81.	SMALL BUSINESS CONSIDERATIONS					
82.	RETROFITTING OF CONVENTIONAL MACHINES					
	AREA 5 ADVANCED TECHNOLOGIES					
83.	N/C VERIFICATION SYSTEMS					
84.	DIRECT NUMERICAL CONTROL (DNC)					
85.	COMPUTER NUMERICAL CONTROL (CNC)					
86.	ADAPTIVE CONTROL (A/C)					
87.	GRAPHIC PART PROGRAMMING					
88.	COMPUTER AIDED DESIGN / INTERACTIVE COMPUTER GRAPHICS					
89.	AUTOMATED DRAWING GENERATION					
90.	MANAGEMENT DATA COLLECTION AND INFORMATION RETRIEVAL					
91.	MACHINE OPERATING COMPENSATION					
92.	MANUFACTURING DATA BASE DESIGN					
93.	COMPUTERIZED MATERIAL HANDLING					
94.	COMPUTER CONTROLLED TRANSFER LINES / ASSEMBLY LINES					
95.	COMPUTERIZED IN-PROCESS INSPECTION					
96.	COMPUTERIZED PRODUCTION SCHEDULING					
97.	COMPUTER AIDED PROCESS CONTROL					
98.	GROUP TECHNOLOGY					
	Additional topics:					

Estimated time to fill out the questionnaire _____

THANK YOU FOR YOUR COOPERATION!

A QUESTIONNAIRE CONCERNING TASKS AND TOPICS FOR EDUCATIONAL TRAINING PROGRAMS IN NUMERICAL CONTROL-COMPUTER AIDED MANUFACTURING

DIRECTIONS: *Please answer the following questions as accurately as possible. All information will be treated confidentially and only in survey summary form.*

1. NAME AND POSITION OF FACULTY MEMBER: _____

2. NAME AND PLACE OF INSTITUTION: _____

3a. NUMBER OF FACULTY IN THE DEPARTMENT:
- ___ Full Time
- ___ Part Time
- ___ Teaching N/C

3b. NUMBER OF STUDENTS IN THE DEPARTMENT:
- ___ Majors
- ___ Non-Majors
- ___ Taking N/C Courses/Year

4a. MAIN TEACHING AREA OF RESPONDENT:
- ___ (Years) Industrial Arts
- ___ (Years) Vocational Education
- ___ (Years) Technical Education
- ___ (Years) Industrial Technology
- ___ (Years) Engineering Technology
- ___ (Years) Total

4b. COMPETENCY IN N/C ACQUIRED THROUGH:
- ___ (Years) Formal Education
- ___ (Years) Correspondence Courses
- ___ (Years) N/C Teaching Experience
- ___ (Years) N/C Work Experience
- ___ (Years) Self-taught
- ___ (Years) Total

5a. NUMBER OF MACHINE TOOLS:

N/C MACHINES		NON N/C
N/C ___	Drilling Machines	___
N/C ___	Milling Machines	___
N/C ___	Lathes	___
N/C ___	Machining Center	___

5b. NUMBER OF N/C CONTROLS:
- ___ Point-to-Point
- ___ P-T-P/Straight Line
- ___ Contour
- ___ Minicomputer

5c. NUMBER OF AXIS:
- ___ 2 - Axis
- ___ 3 - Axis
- ___ 4 - Axis
- ___ 5 or more

6. WHAT IS THE APPROXIMATE PERCENT TIME OF EACH PART PROGRAMMING TECHNIQUE USED?
- ___ Manual Point-to-Point
- ___ Manual P-T-P & Straight Line
- ___ Manual Contour
- ___ Computer (in-house language)
- ___ A P T programming
- ___ Other languages (list)_____

7. LEVEL OF COURSES OFFERED IN N/C: (CHECK)
- ___ Freshman (or 1st yr. Jr. College)
- ___ Sophomore (or 2nd yr. Jr. College)
- ___ Junior (3rd yr. in University)
- ___ Senior (4th yr. in University)

8. DURATION AND SIZE PER N/C COURSE:
- ___ Number of N/C Courses or
- ___ Number of Hours of N/C Instruction
- ___ Lecture / Lab. Hours per Semester Course
- ___ Students per N/C Course
- ___ Students per Laboratory Section
- ___ Students per Academic Year

Do you use a time-share service company (__Check) or your own computer? (__Check)
How many years has your department offered instruction in N/C? (__Years)
How many N/C machine tools and what type are you planning to purchase? _____ (No./ Type)

Additional Comments: _____

NC / CAM TRAINING TOPIC INVENTORY

DIRECTIONS: *This questionnaire consists of a list of tasks and topics in five major areas of NC/CAM that may be included in an educational training program. These areas are: (1) Basic N / C Concepts, (2) Manual Programming, (3) Computer Assisted Programming, (4) Management Aspects, (5) Advanced Technologies.*

Please indicate the relative importance of each topic in your educational program by placing an X in one of the five boxes provided for each item as illustrated in the example below.

RELATIVE VALUE OF IMPORTANCE:

5 - GREAT IMPORTANCE
4 - SUBSTANTIAL IMPORTANCE
3 - MODERATE IMPORTANCE
2 - LIMITED IMPORTANCE
1 - NO IMPORTANCE

AREA 1 BASIC N/C CONCEPTS	IMPORTANCE				
	5 GREAT	4 SUBSTANTIAL	3 MODERATE	2 LIMITED	1 NO
EXAMPLE: PROGRAMMING 4 - AXIS CONTOUR MILLS				X	
1. HISTORY AND DEVELOPMENT OF NUMERICAL CONTROL					
2. BASIC PRINCIPLES OF NUMERICAL CONTROL					
3. COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES					
4. CLASSIFICATION OF N/C CONTROL SYSTEMS					
5. DESIGN AND MANUFACTURING ADVANTAGES					
6. MACHINING AND NON-MACHINING APPLICATIONS					
7. MACHINE AXIS AND MOTION DESCRIPTIONS					
8. ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS, EIA					
9. DECIMAL VERSUS BINARY NUMBER SYSTEMS					
10. SELECTION OF SPEEDS AND FEEDS					
11. CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES					
12. N/C MACHINE SET-UP CONSIDERATIONS					
13. MACHINE CONTROL LOOP AND FEEDBACK					
14. POINT-TO-POINT POSITIONING SYSTEMS					
15. POSITIONING AND STRAIGHT-CUT SYSTEMS					
16. CONTINUOUS PATH CONTOURING SYSTEMS					
17. COMBINATION P-T-P AND CONTOURING SYSTEMS					
18. MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS					

APPENDIX H

Analysis of Variance Table

ANALYSIS OF VARIANCE TABLE
FOR INDUSTRY VERSUS EDUCATION GROUP MEANS

Item No.	Industry Group Mean I	Education Group Mean II	F-Ratio	P
1	2.4545	2.8313	11.843**	0.0010
2	3.9272	4.4167	22.069**	0.0000
3	3.2962	3.8500	19.153**	0.0001
4	2.9121	3.3253	14.105**	0.0004
5	3.6417	3.6585	0.018	0.8892
6	3.4685	3.4881	0.028	0.8611
7	3.7925	4.1667	10.249**	0.0019
8	2.8968	3.2530	8.971**	0.0032
9	2.6702	2.9880	7.071**	0.0080
10	4.2062	4.0723	1.640	0.1978
11	4.1971	3.7711	15.040**	0.0003
12	4.1801	3.8675	8.620**	0.0038
13	3.0293	3.1687	1.375	0.2396
14	3.1432	4.0482	59.482**	0.0000
15	3.2033	3.8659	30.889**	0.0000
16	4.0577	3.6627	13.405**	0.0005
17	3.8420	3.5301	7.212**	0.0075
18	3.4096	2.4819	49.680**	0.0000
19	3.7143	3.4744	3.403	0.0621
20	4.1705	4.1687	0.0	1.0000
21	4.0909	3.7875	6.960**	0.0085
22	3.9433	3.4286	18.645**	0.0001
23	3.6575	3.7857	1.079	0.2997
24	3.6723	4.0119	8.877**	0.0034
25	3.3652	2.7901	20.856**	0.0001
26	3.5609	3.3810	2.180	0.1364
27	3.5987	3.3929	2.897	0.0853
28	3.9937	3.9512	0.131	0.7189
29	3.4530	4.1928	36.335**	0.0000
30	3.2624	4.0000	34.188**	0.0000
31	3.7607	3.3976	8.428**	0.0042
32	3.2184	3.0122	2.709	0.0963
33	3.9167	3.3049	21.780**	0.0000

Note: * significant at the .05 level
** significant at the .01 level

Item No.	Industry Group Mean I	Education Group Mean II	F-Ratio	P
34	3.8645	2.6790	77.092**	0.0000
35	3.7966	3.2222	20.325**	0.0001
36	3.6910	3.6420	0.158	0.6939
37	4.0677	3.5616	15.771**	0.0002
38	3.8636	3.3699	16.335**	0.0002
39	3.3596	2.7971	23.719**	0.0000
40	3.2298	2.5915	25.710**	0.0000
41	3.4009	2.5890	37.419**	0.0000
42	3.6220	2.5556	61.455**	0.0000
43	3.5033	2.9861	11.620**	0.0011
44	3.6746	3.2500	9.210**	0.0029
45	3.6830	3.0986	13.406**	0.0005
46	3.6364	2.9577	18.423**	0.0001
47	3.5366	2.9437	14.450**	0.0004
48	3.5467	2.8714	18.356**	0.0001
49	3.4209	2.6286	26.570**	0.0000
50	3.1378	2.4571	18.904**	0.0001
51	2.9330	2.1286	25.403**	0.0000
52	3.4922	2.6620	30.564**	0.0000
53	3.3736	2.8571	11.754**	0.0010
54	3.9581	3.0563	39.957**	0.0000
55	2.6230	2.5429	0.270	0.6101
56	2.7350	2.2143	11.886**	0.0010
57	2.9911	2.1304	25.747**	0.0000
58	2.2212	1.8986	5.514*	0.0182
59	2.4817	1.7761	19.535**	0.0001
60	2.0446	1.6818	7.453**	0.0066
61	3.7233	2.6800	60.981**	0.0000
62	3.6094	2.6842	53.238**	0.0000
63	3.8259	2.6842	91.844**	0.0000
64	3.7697	2.6494	79.140**	0.0000
65	3.9367	2.9872	58.774**	0.0000
66	3.9872	3.0130	58.184**	0.0000

Note: * significant at the .05 level
** significant at the .01 level

Item No.	Industry Group Mean I	Education Group Mean II	F-Ratio	P
67	3.9852	3.1538	44.390**	0.0000
68	4.0759	2.6104	130.267**	0.0000
69	3.9277	3.2078	37.354**	0.0000
70	3.8429	3.0649	38.031**	0.0000
71	3.9398	2.9474	59.814**	0.0000
72	3.5458	2.7368	36.841**	0.0000
73	3.6521	3.0870	20.588**	0.0001
74	3.3848	2.9118	11.930**	0.0000
75	4.0587	3.2000	52.253**	0.0000
76	3.7593	2.8714	48.001**	0.0000
77	3.5717	2.7681	42.282**	0.0000
78	3.6009	2.7941	39.105**	0.0000
79	3.4803	2.6377	42.475**	0.0000
80	3.7418	2.4714	93.338**	0.0000
81	2.9446	2.2857	20.814**	0.0001
82	2.5175	2.3088	2.248	0.1303
83	3.4703	2.7258	26.417**	0.0000
84	3.3579	2.6563	21.286**	0.0001
85	3.7450	2.8125	40.756**	0.0000
86	3.1667	2.5000	18.713**	0.0001
87	3.2290	2.4286	27.137**	0.0000
88	3.2738	2.6032	16.345**	0.0002
89	2.9264	2.4426	9.035**	0.0032
90	3.3424	2.2903	47.991**	0.0000
91	3.0637	2.1525	39.855**	0.0000
92	3.1002	2.2459	31.704**	0.0000
93	2.7745	2.1905	15.392**	0.0003
94	2.5275	2.1905	4.678*	0.0291
95	2.8902	2.1452	22.077**	0.0000
96	3.2105	2.1429	47.623**	0.0000
97	3.0664	2.2258	28.977**	0.0000
98	3.2940	2.1897	40.650**	0.0000

Note: * significant at the .05 level
** significant at the .01 level

APPENDIX I

Rank Order of the Mean Responses to the NC/CAM Training Topic Inventory

Industrial Group (Part II)

Educational Group (Part II)

INDUSTRY RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
10	SELECTION OF SPEEDS AND FEEDS	4.20
11	CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES	4.19
12	N/C SET-UP CONSIDERATIONS	4.18
20	PART PROGRAMMING FUNDAMENTALS	4.17
21	GEOMETRIC SURFACE DEFINITIONS AND DIMENSIONING	4.09
16	CONTINUOUS PATH CONTOURING SYSTEMS	4.05
68	COMMUNICATIONS AMONG DEPARTMENTS AFFECTED BY N/C	4.07
37	INTRODUCTION TO COMPUTER PROGRAMMING FOR N/C	4.06
75	TOOLING AND FIXTURE DESIGN FOR N/C MACHINING	4.05
28	PROGRAMMING AND TAPE VERIFICATION	3.99
67	JUSTIFICATION AND ECONOMIC EVALUATION OF N/C	3.98
66	EQUIPMENT SELECTION CRITERIA	3.98
71	ORGANIZATION FOR N/C OPERATIONS	3.93
2	BASIC PRINCIPLES OF NUMERICAL CONTROL	3.92
22	LINEAR AND CIRCULAR INTERPOLATION	3.94
65	COST COMPARISON OF N/C VERSUS NON-N/C MACHINES	3.93
69	PART PROGRAMMING REQUIREMENTS	3.92
54	PROGRAM DEBUGGING PROCEDURES	3.95
33	CONTINUOUS PATH CONTOUR PROGRAMMING	3.91
17	COMBINATION P-T-P AND CONTOURING SYSTEMS	3.84
34	PROGRAMMING CONTOUR LATHES	3.86
38	PROGRAMMING SYSTEMS FOR N/C	3.86
70	OBJECTIVES OF THE N/C FACILITY	3.84
63	N/C DIRECT AND INDIRECT COST ESTIMATING	3.82
7	MACHINE AXIS AND MOTION DESCRIPTIONS	3.79

INDUSTRY RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
35	COMBINATION P-T-P AND CONTOUR PROGRAMMING	3.74
64	COST AND PROFIT ESTIMATING	3.72
31	PROGRAMMING FOR MORE THAN 2 - AXIS	3.71
76	MACHINE TOOL OPERATION AND MAINTENANCE PLANNING	3.69
80	MANPOWER SELECTION AND TRAINING	3.68
85	COMPUTER NUMERICAL CONTROL	3.67
61	FORECASTING PRESENT AND FUTURE REQUIREMENTS	3.66
19	BASIC PROCESS FLOW AND JOB PLANNING	3.64
24	TAPE CODES, FORMATS, AND PREPARATION	3.64
36	TAPE VERIFICATION	3.64
23	MANUSCRIPT FORMAT AND PREPARATION	3.62
44	MANUSCRIPT FORMAT AND PREPARATION	3.62
5	DESIGN AND MANUFACTURING ADVANTAGES	3.61
45	POSITIONING AND STRAIGHT-CUT SYSTEMS	3.61
73	MATERIALS AND PROCESS PLANNING	3.59
27	ALLOWANCES FOR CUTTER OFFSET	3.57
42	MINI AND MICRO COMPUTERS FOR N/C APPLICATIONS	3.57
46	APT TRANSFORMATIONS OF GEOMETRY AND CUTTER LOCATIONS	3.57
62	BREAKEVEN CALCULATIONS	3.57
78	QUALITY ASSURANCE AND CONTROL	3.55
26	MACHINING TOLERANCE DEFINITION	3.53
72	PLANT LAYOUT FOR N/C MACHINES VERSUS NON N/C	3.52
77	SETTING STANDARDS AND METHODS	3.52
48	APT REPETITIVE PROGRAMMING	3.49
47	APT TOOL CONTROL	3.48

INDUSTRY RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
43	APT DEVELOPMENT AND CHARACTERISTICS	3.46
6	MACHINING AND NON-MACHINING APPLICATIONS	3.44
52	POST PROCESSOR DEFINITIONS AND ELEMENTS	3.44
79	PRODUCTION SCHEDULING	3.44
29	POINT-TO-POINT PART PROGRAMMING	3.42
83	N/C VERIFICATION SYSTEMS	3.41
18	MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS	3.39
49	MATRIX AND COMPLEX SURFACE DEFINITION	3.38
41	REMOTE CONTROL TIMESHARING	3.37
74	PRODUCT DESIGN AND DEVELOPMENT	3.35
25	MACHINING VECTOR CALCULATIONS	3.34
39	GENERAL SYSTEMS SUPPORT EQUIPMENT	3.33
53	PROCESSING THE APT PART PROGRAM	3.33
84	DIRECT NUMERICAL CONTROL (DNC)	3.32
90	MANAGEMENT DATA COLLECTION AND INFORMATION RETRIEVAL	3.30
3	COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES	3.28
30	STRAIGHT-CUT MACHINING	3.24
88	COMPUTER AIDED DESIGN / INTERACTIVE COMPUTER GRAPHICS	3.24
98	GROUP TECHNOLOGY	3.24
40	GENERAL PROCESS COMPUTER VERSUS STAND-ALONE	3.21
15	POSITIONING AND STRAIGHT-CUT SYSTEMS	3.20
32	TOOL CHANGER INDEXING	3.20
87	GRAPHIC PART PROGRAMMING	3.20
96	COMPUTERIZED PRODUCTION SCHEDULING	3.18
86	ADAPTIVE CONTROL (A/C)	3.15

INDUSTRY RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
14	POINT-TO-POINT POSITIONING SYSTEMS	3.14
50	APT SPECIALIZED GEOMETRIC SURFACES	3.13
92	MANUFACTURING DATA BASE DESIGN	3.10
97	COMPUTER AIDED PROCESS CONTROL	3.06
91	MACHINE OPERATING COMPENSATION	3.06
13	MACHINE CONTROL LOOP AND FEEDBACK	3.02
57	COMPACT II: MANUFACTURING DATA SYSTEMS INC., MDSI	2.99
81	SMALL BUSINESS CONSIDERATIONS	2.94
51	APT PROGRAMMING FOR 4 AND 5 AXIS	2.93
89	AUTOMATED DRAWING GENERATION	2.92
4	CLASSIFICATION OF N/C CONTROL SYSTEMS	2.91
8	ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS, EIA	2.89
95	COMPUTERIZED IN-PROCESS INSPECTION	2.89
93	COMPUTERIZED MATERIAL HANDLING	2.77
56	UNIAPT: UNITED COMPUTING CORPORATION APT	2.73
9	DECIMAL VERSUS BINARY NUMBER SYSTEMS	2.67
55	ADAPT: ADAPTATION OF APT BY IBM	2.62
94	COMPUTER CONTROLLED TRANSFER LINES / ASSEMBLY LINES	2.52
82	RETROFITTING OF CONVENTIONAL MACHINES	2.51
59	ACTION: MANUFACTURING DATA SYSTEMS, INC., MDSI	2.48
1	HISTORY AND DEVELOPMENT OF NUMERICAL CONTROL	2.45
58	SPLIT: SUNDSTRAND PROCESS. LANG. INTERNALLY TRANSLATED	2.22
60	NUFORM: A.S. THOMAS, INC.	2.04

EDUCATION RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
2	BASIC PRINCIPLES OF NUMERICAL CONTROL	4.41
29	POINT-TO-POINT PART PROGRAMMING	4.19
7	MACHINE AXIS AND MOTION DESCRIPTIONS	4.17
20	PART PROGRAMMING FUNDAMENTALS	4.17
10	SELECTION OF SPEEDS AND FEEDS	4.07
14	POINT-TO-POINT POSITIONING SYSTEMS	4.04
24	TAPE CODES, FORMATS, AND PREPARATION	4.00
30	STRAIGHT-CUT MACHINING	4.00
28	PROGRAMMING AND TAPE VERIFICATION	3.95
12	N/C SET-UP CONSIDERATIONS	3.87
15	POSITIONING AND STRAIGHT-CUT SYSTEMS	3.87
3	COORDINATE MEASURING SYSTEM AND N/C DRAFTING PRINCIPLES	3.85
23	MANUSCRIPT FORMATS AND PREPARATION	3.79
21	GEOMETRIC SURFACE DEFINITIONS AND DIMENSIONING	3.79
11	CONSIDERATIONS FOR TOOLING, JIGS AND FIXTURES	3.77
16	CONTINUOUS PATH CONTOURING SYSTEMS	3.66
5	DESIGN AND MANUFACTURING ADVANTAGES	3.66
36	TAPE VERIFICATION	3.64
37	INTRODUCTION TO COMPUTER PROGRAMMING FOR N/C	3.56
17	COMBINATION P-T-P AND CONTOURING SYSTEMS	3.53
6	MACHINING AND NON-MACHINING APPLICATION	3.49
19	BASIC PROCESS FLOW AND JOB PLANNING	3.47
22	LINEAR AND CIRCULAR INTERPOLATION	3.43
27	ALLOWANCES FOR CUTTER OFFSET	3.39
31	PROGRAMMING FOR MORE THAN TWO-AXIS	3.39

EDUCATION RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
26	MACHINING TOLERANCE DEFINITION	3.38
38	PROGRAMMING SYSTEMS FOR N/C	3.37
4	CLASSIFICATION OF N/C CONTROL SYSTEMS	3.32
33	CONTINUOUS PATH CONTOUR PROGRAMMING	3.30
8	ELECTRONIC INDUSTRIES ASSOCIATIONS STANDARDS, EIA	3.25
44	MANUSCRIPT FORMAT AND PREPARATION	3.25
35	COMBINATION OF POINT-TO-POINT AND CONTOUR	3.22
69	PART PROGRAMMING REQUIREMENTS	3.21
75	TOOLING AND FIXTURE DESIGN FOR N/C MACHINING	3.20
13	MACHINE CONTROL LOOP AND FEEDBACK	3.17
67	JUSTIFICATION AND ECONOMIC EVALUATION OF N/C EQUIPMENT	3.15
45	APT CONVENTIONS, WORDS AND GEOMETRIC DEFINITIONS	3.10
73	MATERIALS AND PROCESS PLANNING	3.08
70	OBJECTIVES OF THE N/C FACILITY	3.07
54	PROGRAM DEBUGGING PROCEDURES	3.05
32	TOOL CHANGER INDEXING	3.01
66	EQUIPMENT SELECTION CRITERIA	3.01
9	DECIMAL VERSUS BINARY NUMBER SYSTEMS	2.99
43	APT DEVELOPMENT AND CHARACTERISTICS	2.99
65	COST COMPARISON OF N/C VERSUS NON N/C MACHINES	2.99
46	APT TRANSFORMATIONS OF GEOMETRY AND CUTTER LOCATIONS	2.96
47	APT TOOL CONTROL	2.95
71	ORGANIZATION FOR N/C OPERATIONS	2.95
74	PRODUCT DESIGN AND DEVELOPMENT	2.91
48	APT REPETITIVE PROGRAMMING	2.87

EDUCATION RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
76	MACHINE TOOL OPERATION AND MAINTENANCE PLANNING	2.87
53	PROCESSING THE APT PART PROGRAM	2.86
1	HISTORY AND DEVELOPMENT OF NUMERICAL CONTROL	2.83
85	COMPUTER NUMERICAL CONTROL (CNC)	2.81
39	GENERAL SYSTEMS SUPPORT EQUIPMENT	2.79
78	QUALITY ASSURANCE AND CONTROL	2.79
25	MACHINING VECTOR CALCULATIONS	2.79
77	SETTING STANDARDS AND METHODS	2.77
83	N/C VERIFICATION SYSTEMS	2.73
72	PLANT LAYOUT FOR N/C MACHINES VERSUS NON N/C	2.73
61	FORECASTING PRESENT AND FUTURE REQUIREMENTS	2.68
62	BREAKEVEN CALCULATIONS	2.68
63	N/C DIRECT AND INDIRECT COST ESTIMATING	2.68
34	PROGRAMMING CONTOUR LATHES	2.67
52	POST PROCESSOR DEFINITIONS AND ELEMENTS	2.66
84	DIRECT NUMERICAL CONTROL (DNC)	2.66
79	PRODUCTION SCHEDULING	2.64
64	COST AND PROFIT ESTIMATING	2.64
49	MATRIX AND COMPLEX SURFACE DEFINITION	2.63
68	COMMUNICATIONS AMONG DEPARTMENTS AFFECTED BY N/C	2.61
40	GENERAL PROCESS COMPUTER VERSUS STAND-ALONE	2.60
88	COMPUTER AIDED DESIGN / INTERACTIVE COMPUTER GRAPHICS	2.60
41	REMOTE CONTROL TIMESHARING	2.59
42	MINI AND MICRO COMPUTERS FOR N/C APPLICATIONS	2.55
55	ADAPT: ADAPTATION OF APT BY IBM	2.54

EDUCATION RANK ORDER OF THE MEANS

ITEM	NC / CAM TRAINING TOPICS	MEAN*
86	ADAPTATIVE CONTROL (A/C)	2.50
18	MAINTENANCE CONCEPTS OF CONTROLLERS AND TAPE READERS	2.48
80	MANPOWER SELECTION AND TRAINING	2.47
50	APT SPECIALIZED GEOMETRIC SURFACES	2.45
89	AUTOMATED DRAWING GENERATION	2.44
87	GRAPHIC PART PROGRAMMING	2.43
82	RETROFITTING OF CONVENTIONAL MACHINES	2.30
90	MANAGEMENT DATA COLLECTION AND INFORMATION RETRIEVAL	2.29
81	SMALL BUSINESS CONSIDERATIONS	2.28
92	MANUFACTURING DATA BASE DESIGN	2.24
97	COMPUTER AIDED PROCESS CONTROL	2.22
56	UNIAPT: UNITED COMPUTING CORPORATION APT	2.21
91	MACHINE OPERATING COMPENSATION	2.19
93	COMPUTERIZED MATERIAL HANDLING	2.19
94	COMPUTER CONTROLLED TRANSFER LINES / ASSEMBLY LINES	2.19
98	GROUP TECHNOLOGY	2.19
95	COMPUTERIZED IN-PROCESS INSPECTION	2.14
96	COMPUTERIZED PRODUCTION SCHEDULING	2.14
51	APT PROGRAMMING FOR 4 AND 5 AXIS	2.13
57	COMPACT II: MANUFACTURING DATA SYSTEMS INC., MDSI	2.13
58	SPLIT: SUNDSTRAND PROCESS. LANG. INTERNALLY TRANSLATED	1.89
59	ACTION: MANUFACTURING DATA SYSTEMS, INC., MDSI	1.77
60	NUFORM: A.S. THOMAS, INC.	1.68

APPENDIX J

Input Data Code Sheets for Survey Result Tables

Industrial Group (Part I-A and I-B)

Educational Group (Part I-A and I-B)

CODE SHEET FOR DATA INPUT
OF INDUSTRY RESPONSES

Quest. No.	Var. No.	(Card A)	Col. No.	Col. Location
		STANDARD INDUSTRIAL CLASSIFICATION CODE (SIC) 34--FABRICATED METAL PRODUCTS 35--MACHINERY, EXC. ELECTRICAL 354-METALWORKING MACHINERY 355-SPECIAL INDUSTRY MACHINERY 359-MISC. MACHINERY EXCEPT ELECTRICAL 36--ELECTRICAL AND ELECTRONIC EQUIP. 37--TRANSPORTATION EQUIP. 38--INSTRUMENTS AND RELATED PROD. 60--ADMINISTRATIVE AND AUXILLARY 01--OTHERS	3	1- 3
		NO. OF CARDS PER RESPONDENT (A,B,C,D) A- 1 B- 2 C- 3 D- 4	1	4
1.		POSITION OF RESPONDENT (1-9) 1--PRESIDENT (VICE P.) 2--MANAGER (PRODUCTION) 3--MANAGER (SALES) 4--DIRECTOR 5--SUPERVISOR (PRODUCTION) 6--N/C PROGRAMMER 7--ENGINEER 8--TECHNICIAN 9--OWNER	1	5
2.		GEOGRAPHIC LOCATION (1-50) (REFER TO SEPARATE LOCATION CODE)	2	6- 7
3a.		NO. OF EMPLOYEES IN PLANT (1-8) 1--1-24 2--25-99 3--100-249 4--250-499 5--500-999 6--1000-2499 7--2500-4999 8--5000 OR MORE	1	8
		BLANK		9-13
3b.		NO. OF N/C-PERSONNEL IN PLANT		
	1.	OPERATORS	2	14-15
	2.	N/C-MAINTENANCE PERSONNEL	2	16-17
	3.	N/C-SUPERVISOR	2	18-19
	4.	N/C-PROGRAMMERS	2	20-21
		BLANK		22
4a.		MAIN WORK AREA OF RESPONDENT (YRS)		

Quest. No.	Var. No.	Continuation Card A	Col. No.	Col. Location
	5.	DESIGN	2	23-24
	6.	PRODUCTION	2	25-26
	7.	PROGRAMMING	2	27-28
	8.	MAINTENANCE	2	29-30
	9.	TOOLING	2	31-32
	10.	SALES	2	33-34
	11.	RESEARCH	2	35-36
	12.	NO. OF YEARS IN OTHER AREA	1	37
	13.	1= MANAGER 2= IND. ENGINEERING 3= OTHER	1	38
		BLANK		39
4b.		COMPETENCY IN N/C ACQUIRED THRU (YRS.)		
	14.	FORMAL EDUCATION	2	40-41
	15.	CORRESPONDENCE	2	42-43
	16.	N/C WORK EXPERIENCE	2	44-45
	17.	SELF-TAUGHT	2	46-47
		BLANK		48
5a.		NO. OF N/C MACHINES	2	
	18.	DRILLING	2	49-50
	19.	MILLING	2	51-52
	20.	LATHES	2	53-54
	21.	MACHINING CENTERS	2	55-56
	22.	GRINDERS	1	57
	23.	PUNCH PRESSES	1	58
	24.	FLAME CUTTERS	1	59
5b.		NO. OF N/C CONTROLS		
	25.	(P-T-P)	2	60-61
	26.	(P-T-P/STRAIGHT LINE)	2	62-63
	27.	CONTOUR	2	64-65
	28.	MINICOMPUTER	2	66-67
	29.	NO. OTHER TYPE OF N/C CONTROLS	2	68-69
	30.	1--CNC 2--DNC 3--MICROPROCESSOR 4--OTHER	1	70
5c.		NO. OF N/C AXIS		
	31.	2-AXIS	2	71-72
	32.	3-AXIS	2	73-74
	33.	4-AXIS	2	75-76
	34.	5-AXIS	2	77-78
	35.	NO. OF OTHER TYPE	1	79
	36.	1--2+2 AXIS 2--OTHERS	1	80

CODE SHEET FOR DATA INPUT
OF INDUSTRY RESPONSES

Quest. No.	Var. No.	(Card B)	Col. No.	Col. Location
Identification		Same as Card A	8	1- 8
		BLANK		9-10
6.		APPROXIMATE PERCENT TIME		
	1	MANUAL P-to-P	3	11-13
	2	P-to-P/STRAIGHT LINE	3	14-16
	3	MANUAL CONTOUR	3	17-19
	4	COMPUTER-IN HOUSE LANGUAGE	3	20-22
	5	APT-PROGRAMMING	3	23-25
	6	PERCENT OF OTHER LANGUAGE	2	26-27
	7	TYPE OF OTHER LANGUAGE (1-9) 1--COMPACT II (MDSI) 2--ADAPT 3--UNIAPT 4--SPLIT 5--ACTION 6--LEBLOND (TOOL PATH) 7--GETURN 8--INTERACTIVE GRAPHICS, CAD 9--OTHERS	1	28
		BLANK		29
7.		APPROXIMATE PERCENTAGE FOR TRAINING		
	8	IN HOUSE	3	30-32
	9	EQUIPMENT MANUFACTURERS	3	33-35
	10	CONTROL MANUFACTURERS	3	36-38
	11	SERVICE BUREAUS	3	39-41
	12	HIGHER EDUCATION INSTITUTIONS	3	42-44
	13	VOCATIONAL/TECHN. HIGH SCHOOL	3	45-47
	14	JUNIOR OR COMMUNITY COLLEGE	3	48-50
	15	PERCENTAGE OF OTHER TRAINING	2	51-52
		BLANK		53
	16	TYPES OF OTHER TRAINING (1,2,3) 1= INDUSTRY 2= SOFTWARE SERVICES, NCS, SME, MDSI 3= OTHER	1	54
8a.		ESTIMATED NO. OF NEW PERSONNEL FOR THE NEXT 5 YRS.		
	17	MANUAL PROGRAMMERS	2	55-56
	18	APT PROGRAMMERS	2	57-58
	19	NO. OF OTHER PROGRAMMERS	1	59
	20	TYPE OF OTHER PROGRAMMERS (1-9) 1-- COMPACT II (MDSI) 2-- ADAPT 3-- UNIAPT 4-- APLIT 5-- DNC OR CNC	1	60

Quest. No.	Var. No.		Col. No.	Col. Location
		6-- SOFTWARE/SYSTEMS 7-- COMPUTER GRAPHICS 8-- POST PROCESSOR 9-- OTHERS		
8b.	21	N/C MACHINE OPERATORS	2	61-62
	22	N/C MAINTENANCE PERSONNEL	2	63-64
	23	N/C SUPERVISORS	2	65-66
	24	NO. OF OTHERS	1	67
	25	TYPE OF OTHERS (1,2) 1-- SERVICE/FIELD PERSONNEL 2-- OTHERS	1	68
	26	TIME SHARE OR OWN COMPUTERS (1,2,3) 1= TIME SHARE 2= OWN COMPUTER 3= BOTH	1	69
9.	27	YRS. USE N/C MACHINING TOOLS	2	70-71
10.	28	NO. OF N/C DRILLS TO BUY	1	72
	29	MILLS	1	73
	30	LATHE	1	74
	31	MACHINING CENTERS	1	75
	32	GRINDERS	1	76
	33	PUNCH	1	77
	34	FLAME CUTTER	1	78
	35	OTHER	1	79
11.	36	NO. OF ADDITIONAL COMMENTS (1,2,3, etc.)	1	80

CODE SHEET FOR DATA INPUT
OF EDUCATION RESPONSES

Quest. No.	Var. No.	(Card A)	Col. No.	Col. Location
Identification				
		TYPE OF SCHOOL (IA,ET,JC) IA--INDUSTRIAL ARTS ET--ENGINEERING TECHNOLOGY JC--JUNIOR COLLEGE	2	1- 2
		STATUS OF N/C INSTRUCTION (P.F.N) P--PRESENT F--FUTURE N--NONE	1	3
		NO. OF CARDS PER RESPONDENT (A,B,C,D) A--1 B--2 C--3 D--4	1	4
1.		POSITION OF RESPONDENT (1-9) 1--TEACHER 2--INSTRUCTOR 3--LECTURER 4--ASSISTANT PROFESSOR 5--ASSOCIATE PROFESSOR 6--PROFESSOR 7--DIVISION CHAIRMAN, DIRECTOR COORDINATOR 8--DEPT. CHAIRMAN, (DEAN) AND UP, HEAD 9--OTHER	1	5
2.		GEOGRAPHIC LOCATION (01-50) REFER TO SEPARATE LOCATION CODE	2	6- 7
3a.		NO. OF FACULTY IN DEPT. (1-9) 1--1-3 2--4-6 3--7-10 4--11-15 5--16-20 6--21-25 7--25-30 8--31-40 9--41-50	1	8
		BLANK		9-10
3a. cont.	1	NO. OF FACULTY IN THE DEPT. FULL TIME	3	11-13
	2	PART TIME	3	14-16
	3	TEACHING N/C	3	17-19
3b.		NO. OF STUDENTS IN THE DEPT.		
	4	MAJORS	3	20-22
	5	NON-MAJORS	3	23-25
	6	TAKING N/C COURSES	3	26-28
4a.		MAIN TEACHING AREA OF RESPONDENT		

Quest. No.	Var. No.	Continuation Card A	Col. No.	Col. Location
	7	IND. ARTS	2	29-30
	8	VOCATIONAL EDU.	2	31-32
	9	TECHNICAL EDU.	2	33-34
	10	IND. TECHNOLOGY	2	35-36
	11	ENG. TECHNOLOGY	2	37-38
	12	TOTAL	2	39-40
4b.		COMPETENCY IN N/C ACQUIRED THROUGH		
	13	FORMAL EDU.	2	41-42
	14	CORRESPONDENCE COURSES	2	43-44
	15	N/C TEACHING EXPERIENCE	2	45-46
	16	N/C WORK EXPERIENCE	2	47-48
	17	SELF-TAUGHT	2	49-50
	18	TOTAL	2	51-52
5a.		NO. OF MACHINE TOOLS		
	19	N/C DRILLING	2	53-54
	20	N/C MILLING	2	55-56
	21	N/C LATHES	2	57-58
	22	N/C MACHINING CENTERS	2	59-60
		NO. OF NON N/C TOOLS		
	23	DRILLING	2	61-62
	24	MILLING	2	63-64
	25	LATHES	2	65-66
	26	MACHINING CENTERS	2	67-68

CODE SHEET FOR DATA INPUT
OF EDUCATION RESPONSES

Quest. No.	Var. No.	(Card B)	Col. No.	Col. Location
Identification		Same as Card A	8	1- 8
		BLANK		9-10
5b.		NO. OF N/C CONTROLS		
	1	P-to-P	2	11-12
	2	P-to-P/STRAIGHT LINE	2	13-14
	3	CONTOUR	2	15-16
	4	MINICOMPUTER	2	17-18
5c.		NO. OF AXIS		
	5	2-AXIS	2	19-20
	6	3-AXIS	2	21-22
	7	4-AXIS	2	23-24
	8	5-AXIS	2	25-26
6.		APPROXIMATE PERCENT TIME OF EACH PART PROGRAMMING TECH. USED		
	9	MANUAL P-to-P	3	27-29
	10	MANUAL P-to-P/STRAIGHT LINE	3	30-32
	11	MANUAL CONTOUR	3	33-35
	12	COMPUTER	3	36-38
	13	APT-PROGRAMMING	3	39-41
	14	TYPE OF OTHER LANGUAGE	1	42-
	15	NO. OF OTHER LANGUAGE	2	43-44
	16	TYPE OF OTHER LANGUAGE	1	45-
	17	NO. OF OTHER LANGUAGE	2	46-47
7.		LEVEL OF COURSES OFFERED IN N/C		
	18	FRESHMAN	2	48-49
	19	SOPHMORE	2	50-51
	20	JUNIOR	2	52-53
	21	SENIOR	2	54-55
8.		DURATION AND SIZE PRE N/C COURSE		
	22	NO. OF N/C COURSES	2	56-57
	23	NO. OF HOURS OF N/C INSTRUCTIONS	2	58-59
	24	LECTURE (HOURS PER SEMESTER)	2	60-61
	25	LAB (HOURS PER SEMESTER)	2	62-63
	26	STUDENT PER N/C COURSE	2	64-65
	27	STUDENT PER LAB	2	66-67
	28	STUDENT PER ACADEMIC YEAR	2	68-69
9.	29	TIME-SHARE SERVICE OR OWN COMPUTER (1,2,3) 1-TIME SHARE 2-OWN COMPUTER 3-BOTH	2	70-71
10.	30	NO. OF YEARS OFFER INSTRUCTION	2	72-73
11.		NO. OF MACHINE TO BUY AND TYPE		
	31	NO.-DRILLS	1	74
	32	NO.-MILLS	1	75
	33	NO.-LATHES	1	76
	34	NO.-MACHINING CENTERS	1	77
	35	NO.-GRINDERS	1	78
	36	NO.-OTHERS	1	79

GEOGRAPHIC LOCATION CODE

(Column Location 6-7)

1-Alaska	AK	26-Montana	MT
2-Alabama	AL	27-Nebraska	NB
3-Arizona	AZ	28-Nevada	NV
4-Arkansas	AR	29-New Hampshire	NH
5-California	CA	30-New Jersey	NJ
6-Colorado	CO	31-New Mexico	NM
7-Connecticut	CT	32-New York	NY
8-Delaware	DE	33-North Carolina	NC
9-Florida	FL	34-North Dakota	ND
10-Georgia	GA	35-Ohio	OH
11-Hawaii	HI	36-Oklahoma	OK
12-Idaho	ID	37-Oregon	OR
13-Illinois	IL	38-Pennsylvania	PA
14-Indiana	IN	39-Rhode Island	RI
15-Iowa	IA	40-South Carolina	SC
16-Kansas	KS	41-South Dakota	SD
17-Kentucky	KY	42-Tennessee	TN
18-Louisiana	LA	43-Texas	TX
19-Maine	ME	44-Utah	UT
20-Maryland	MD	45-Vermont	VT
21-Massachusetts	MA	46-Virginia	VA
22-Michigan	MI	47-Washington	WA
23-Minnesota	MN	48-West Virginia	WV
24-Mississippi	MS	49-Wisconsin	WI
25-Missouri	MO	50-Wyoming	WY
		51-District of Columbia	DC

APPENDIX K

Survey Result Table for

Industrial Group (Part I-A) of Survey Instrument

Number of N/C-Personnel in Plant

Main Work Area of Respondent in Years

Competency in N/C acquired

Number of N/C Machines

Number of N/C Controls

Number of Axis

Note: THE FOLLOWING TABLES SUMMARIZE ALL ORIGINAL RESPONSES BY INDUSTRIAL AND EDUCATIONAL SURVEY PARTICIPANTS

All responses are Raw Scores and Means are not adjusted for overall number of responses per group of questions (as underlined with asterisks).

Therefore, since multiple answers per group of questions occur frequently, Means are not cumulative and percentages of all questions within groups do not total 100 percent.

Tables in Chapter IV, however, are adjusted for individual question mean responses by taking into account the overall number of responses per group of questions. This accounts for possible differences between Raw Score Means and adjusted means as described in the data analysis.

NUMBER OF N/C PERSONNEL IN PLANT
****

NUMBER OF N/C OPERATORS PER PLANT

VARIABLE 1 MEAN = 21.1135
NUMBER OF RESPONSES = 326. RESPONSE PERCENTAGE= 78.18

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	8	2	1	41
2.	18	6	5	42
3.	23	7	12	42
4.	24	7	19	43
5.	14	4	25	43
6.	16	5	29	43
7.	14	4	34	44
8.	16	5	38	44
9.	16	5	43	45
10.	11	3	47	45
11.	7	2	50	45
12.	18	6	54	46
13.	3	1	57	46
14.	9	3	59	47
15.	7	2	62	47
16.	4	1	63	47
18.	7	2	65	48
19.	2	1	66	49
20.	9	3	68	49
21.	1	0	69	49
22.	3	1	70	50
23.	4	1	71	50
24.	6	2	73	51
25.	5	2	74	51
26.	1	0	75	51
27.	1	0	76	52
28.	1	0	76	52
30.	17	5	79	53
33.	1	0	81	54
35.	1	0	82	55
36.	2	1	82	55
38.	2	1	83	56
39.	1	0	83	57

NOTE: Tables list original survey responses for each of 36 questions to Part I-A of the questionnaire for a total of 417 companies responding in the following manner:

(1) Variable Number corresponds to the same number on the Input Data Code Sheets.

(2) Mean represents the average (number or percentage) of all raw scores and their respective frequencies to the particular question.

(3) Number of Responses refers to the completed answers to each question only.

(4) Response Percentage is based on the total number of questionnaires received and the number of responses per question.

(5) Raw Score and Frequency list all individual answers with the respective number each value occurs (frequency).

(6) Percentage, Percentile, Standard list the specific distribution of each response per question.

40.	4	1	84	57
41.	1	0	85	58
45.	4	1	86	59
46.	1	0	86	60
48.	1	0	87	60
50.	8	2	88	61
54.	1	0	89	63
58.	1	0	90	64
60.	4	1	90	65
63.	1	0	91	66
64.	1	0	92	67
65.	1	0	92	67
70.	4	1	93	69
75.	1	0	93	71
80.	4	1	94	73
90.	1	0	95	77
94.	1	0	95	79
99.	15	5	98	81

NUMBER OF N/C MAINTENANCE PERSONNEL PER PLANT

VARIABLE 2 MEAN = 5.2721
NUMBER OF RESPONSES = 272. RESPONSE PERCENTAGE= 65.23

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	69	25	13	45
2.	71	26	38	46
3.	37	14	58	47
4.	19	7	69	48
5.	17	6	75	49
6.	10	4	80	50
7.	1	0	82	51
8.	4	1	83	53
9.	3	1	84	54
10.	12	4	87	55
12.	4	1	90	57
13.	1	0	91	58
14.	1	0	91	59
15.	6	2	93	60
18.	1	0	94	64
20.	5	2	95	66
24.	2	1	96	70
25.	1	0	97	72
28.	1	0	97	75
30.	3	1	98	77
32.	1	0	99	79
50.	2	1	99	99
99.	1	0	99	99

MAIN WORK AREA OF RESPONDENT IN YEARS
****

MAIN WORK AREA OF RESPONDENT IN YEARS: DESIGN

VARIABLE 5 MEAN = 6.5062
NUMBER OF RESPONSES = 81. RESPONSE PERCENTAGE= 19.42

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	9	4	39
2.	13	16	17	41
3.	10	12	31	43
4.	4	5	40	45
5.	9	11	48	46
6.	4	5	56	48
7.	1	1	59	50
8.	6	7	63	52
9.	9	11	72	54
10.	10	12	84	56
12.	2	2	91	60
15.	1	1	93	66
16.	1	1	94	68
20.	2	2	96	76
23.	1	1	98	82
25.	1	1	99	86

MAIN WORK AREA OF RESPONDENT IN YEARS: PRODUCTION

VARIABLE 6 MEAN = 8.4928
NUMBER OF RESPONSES = 138. RESPONSE PERCENTAGE= 33.09

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	9	7	3	38
2.	15	11	12	40
3.	11	8	21	41
4.	12	9	30	43
5.	14	10	39	44
6.	3	2	45	46
7.	2	1	47	47
8.	7	5	50	49
9.	22	16	61	50
10.	10	7	72	52
11.	2	1	77	53
12.	2	1	78	55
13.	2	1	80	56
14.	1	1	81	58
15.	10	7	85	59
17.	1	1	89	62
18.	2	1	90	64
20.	7	5	93	67
22.	1	1	96	70
24.	1	1	97	73
25.	1	1	97	74
28.	1	1	98	79
33.	1	1	99	87
35.	1	1	99	90

MAIN WORK AREA OF RESPONDENT IN YEARS: PROGRAMMING

VARIABLE 7 MEAN = 7.1985
NUMBER OF RESPONSES = 267. RESPONSE PERCENTAGE= 64.01

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	13	5	2	33
2.	18	7	8	35
3.	18	7	15	38
4.	30	11	24	41
5.	22	8	34	44
6.	13	5	40	46
7.	11	4	45	49
8.	22	8	51	52
9.	59	22	66	54
10.	27	10	82	57
11.	3	1	88	60
12.	12	4	91	63
13.	7	3	94	65
14.	3	1	96	68
15.	5	2	98	71
17.	2	1	99	76
18.	1	0	99	79
20.	1	0	99	84

MAIN WORK AREA OF RESPONDENT IN YEARS: MAINTENANCE

VARIABLE 8 MEAN = 5.7381
NUMBER OF RESPONSES = 42. RESPONSE PERCENTAGE= 10.07

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	17	8	39
2.	6	14	24	41
3.	2	5	33	43
4.	3	7	39	46
5.	6	14	50	48
6.	2	5	60	50
7.	2	5	64	52
8.	1	2	68	55
9.	9	21	80	57
10.	1	2	92	59
12.	2	5	95	64
25.	1	2	99	93

MAIN WORK AREA OF RESPONDENT IN YEARS: TOOLING

VARIABLE 9 MEAN = 7.4464
NUMBER OF RESPONSES = 112. RESPONSE PERCENTAGE= 28.86

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	9	8	4	41
2.	14	13	14	42
3.	11	10	25	43
4.	13	12	36	45
5.	17	15	50	46
6.	6	5	60	48
8.	3	3	64	50
9.	17	15	73	52
10.	5	4	83	53
11.	1	1	85	54
13.	1	1	86	57
14.	1	1	87	58
15.	2	2	88	60
16.	1	1	90	61
17.	1	1	91	62
18.	1	1	92	64
20.	3	3	93	66
22.	1	1	95	69
23.	1	1	96	71
25.	1	1	97	73
30.	1	1	98	80
35.	1	1	99	87
50.	1	1	99	99

MAIN WORK AREA OF RESPONDENT IN YEARS: SALES

VARIABLE 10 MEAN = 7.0690
NUMBER OF RESPONSES = 58. RESPONSE PERCENTAGE= 13.91

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	3	2	37
2.	7	12	9	39
3.	9	16	23	41
4.	4	7	34	43
5.	4	7	41	45
6.	1	2	46	47
7.	3	5	49	49
8.	2	3	53	51
9.	18	31	71	53
10.	3	5	89	56
12.	1	2	92	60
20.	3	5	96	76
24.	1	2	99	84

MAIN WORK AREA OF RESPONDENT IN YEARS: RESEARCH

VARIABLE 11 MEAN = 6.9091
NUMBER OF RESPONSES = 55. RESPONSE PERCENTAGE= 13.19

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	5	3	38
2.	10	18	15	40
3.	4	7	27	42
4.	5	9	35	44
5.	4	7	44	46
6.	3	5	50	48
7.	3	5	55	50
9.	13	24	70	54
10.	3	5	85	56
11.	1	2	88	58
14.	1	2	90	64
16.	1	2	92	68
17.	1	2	94	70
18.	2	4	96	72
25.	1	2	99	86

MAIN WORK AREA OF RESPONDENT IN YEARS: OTHER AREAS

VARIABLE 12 MEAN = 6.3654
NUMBER OF RESPONSES = 52. RESPONSE PERCENTAGE= 12.47

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	4	2	29
2.	2	4	6	33
3.	6	12	13	37
4.	8	15	27	41
5.	2	4	37	44
6.	4	8	42	48
7.	5	10	51	52
8.	1	2	57	56
9.	22	42	79	59

MAIN WORK AREA OF RESPONDENT IN YEARS:
(1=MANAGER;2=INDUSTRIAL ENGG.;3=OTHER)

VARIABLE 13 MEAN = 2.0606
NUMBER OF RESPONSES = 66. RESPONSE PERCENTAGE= 15.83

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	22	33	17	38
2.	21	32	49	49
3.	21	32	81	60
4.	1	2	98	71
5.	1	2	99	81

14.	5	1	88	58
15.	14	4	91	59
16.	4	1	93	61
17.	3	1	94	62
18.	8	2	96	64
19.	1	0	97	65
20.	7	2	98	67
21.	1	0	99	68
99.	1	0	99	99

YEARS SELF TAUGHT

VARIABLE 17 MEAN = 6.2466
NUMBER OF RESPONSES = 146. RESPONSE PERCENTAGE= 35.01

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	23	16	8	38
2.	24	16	24	41
3.	8	5	35	43
4.	12	8	42	45
5.	8	5	49	47
6.	6	4	53	49
7.	3	2	57	51
8.	7	5	60	53
9.	27	18	72	55
10.	12	8	85	57
12.	5	3	91	62
13.	1	1	93	64
15.	3	2	94	68
16.	1	1	96	70
17.	1	1	96	72
18.	1	1	97	74
20.	2	1	98	78
21.	1	1	99	81
23.	1	1	99	85

NUMBER OF N/C MACHINES
****

NUMBER OF N/C DRILLING MACHINES

VARIABLE 18 MEAN = 5.2036
NUMBER OF RESPONSES = 221. RESPONSE PERCENTAGE= 53.00

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	58	26	13	45
2.	39	18	35	46
3.	30	14	51	47
4.	31	14	64	48
5.	15	7	75	49
6.	8	4	80	50
7.	6	3	83	52
8.	7	3	86	53
9.	4	2	89	54

COMPETENCY IN N/C ACQUIRED

****

YEARS OF FORMAL EDUCATION

VARIABLE 14 MEAN = 5.9451
NUMBER OF RESPONSES = 164. RESPONSE PERCENTAGE= 39.33

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	40	24	12	40
2.	38	23	36	42
3.	2	1	48	44
4.	18	11	54	46
5.	6	4	62	48
6.	2	1	64	50
7.	1	1	65	51
8.	2	1	66	53
9.	12	7	70	55
10.	2	1	74	57
12.	11	7	78	61
13.	1	1	82	62
14.	11	7	86	64
15.	5	3	91	66
16.	10	6	95	68
18.	3	2	99	72

YEARS OF CORRESPONDENCE COURSES

VARIABLE 15 MEAN = 3.0943
NUMBER OF RESPONSES = 53. RESPONSE PERCENTAGE= 12.71

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	22	42	21	43
2.	13	25	54	46
3.	5	9	71	49
4.	4	8	79	52
9.	7	13	90	69
11.	2	4	98	76

YEARS OF WORK EXPERIENCE

VARIABLE 16 MEAN = 8.3491
NUMBER OF RESPONSES = 338. RESPONSE PERCENTAGE= 81.06

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	12	4	2	39
2.	26	8	7	40
3.	25	7	15	42
4.	21	6	22	43
5.	29	9	29	45
6.	15	4	36	46
7.	22	7	41	47
8.	26	8	48	49
9.	54	16	60	50
10.	34	10	73	52
11.	9	3	79	53
12.	14	4	83	55
13.	7	2	86	56

NUMBER OF N/C LATHES

VARIABLE 20 MEAN = 6.3612
NUMBER OF RESPONSES = 263. RESPONSE PERCENTAGE= 63.07

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	64	24	12	45
2.	63	24	36	46
3.	37	14	55	47
4.	25	10	67	48
5.	13	5	74	48
6.	12	5	79	49
7.	6	2	83	50
8.	6	2	85	51
9.	5	2	87	52
10.	1	0	88	52
11.	4	2	89	53
12.	4	2	90	54
13.	1	0	91	55
14.	1	0	92	55
16.	2	1	92	57
17.	1	0	93	58
18.	2	1	94	58
20.	1	0	94	60
22.	1	0	94	62
23.	1	0	95	62
27.	1	0	95	65
30.	2	1	96	68
31.	1	0	96	68
36.	1	0	97	72
40.	1	0	97	75
55.	1	0	98	87
56.	1	0	98	88
72.	1	0	98	99
75.	1	0	99	99
80.	1	0	99	99
90.	1	0	99	99
99.	1	0	99	99

NUMBER OF N/C MACHINING CENTERS

VARIABLE 21 MEAN = 5.0000
NUMBER OF RESPONSES = 245. RESPONSE PERCENTAGE= 58.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	64	26	13	45
2.	51	21	37	46
3.	36	15	54	47
4.	15	6	65	48
5.	15	6	71	50
6.	10	4	76	51
7.	13	5	81	52
8.	3	1	84	53
9.	8	3	86	54
10.	8	3	89	55
11.	2	1	91	57
12.	3	1	92	58
13.	2	1	93	59
14.	2	1	94	60

10.	3	1	90	55
12.	6	3	92	58
13.	1	0	94	59
14.	2	1	95	60
16.	1	0	95	62
20.	2	1	96	67
24.	1	0	97	72
30.	2	1	97	79
41.	1	0	98	92
44.	1	0	98	95
50.	1	0	99	99
60.	1	0	99	99
65.	1	0	99	99

NUMBER OF N/C MILLING MACHINES

VARIABLE 19 MEAN = 6.7340
NUMBER OF RESPONSES = 203. RESPONSE PERCENTAGE= 48.68

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	51	25	13	45
2.	36	18	34	46
3.	29	14	50	47
4.	19	9	62	47
5.	23	11	72	48
6.	5	2	79	49
7.	3	1	81	50
8.	5	2	83	50
9.	7	3	86	51
10.	2	1	88	52
11.	1	0	89	53
12.	2	1	90	54
13.	1	0	90	54
15.	2	1	91	56
16.	1	0	92	57
17.	1	0	92	57
19.	1	0	93	59
20.	1	0	93	60
23.	1	0	94	62
25.	2	1	95	64
26.	1	0	95	64
40.	2	1	96	75
45.	1	0	97	79
50.	1	0	97	83
60.	2	1	98	91
68.	1	0	99	97
81.	1	0	99	99
99.	1	0	99	99

15.	2	1	95	62
18.	3	1	96	65
19.	1	0	97	67
20.	1	0	97	68
22.	2	1	98	70
28.	1	0	99	78
33.	1	0	99	84
50.	1	0	99	99
99.	1	0	99	99

NUMBER OF N/C GRINDERS

VARIABLE 22 MEAN = 1.5556
NUMBER OF RESPONSES = 9. RESPONSE PERCENTAGE= 2.16

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	78	39	45
2.	1	11	83	53
5.	1	11	94	77

NUMBER OF N/C PUNCH PRESSES

VARIABLE 23 MEAN = 2.0294
NUMBER OF RESPONSES = 34. RESPONSE PERCENTAGE= 8.15

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	19	56	28	43
2.	7	21	66	49
3.	3	9	81	55
4.	3	9	90	61
6.	1	3	96	73
9.	1	3	99	90

NUMBER OF N/C FLAME CUTTERS

VARIABLE 24 MEAN = 2.1111
NUMBER OF RESPONSES = 9. RESPONSE PERCENTAGE= 2.16

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	67	33	45
2.	2	22	78	49
9.	1	11	94	77

NUMBER OF N/C CONTROLS
****

NUMBER CF N/C CONTROLS: POINT-TO-POINT

VARIABLE 25 MEAN = 5.3045
NUMBER OF RESFCNSES = 243. RESPONSE PERCENTAGE= 58.27

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	56	23	12	45
2.	53	22	34	46
3.	32	13	51	47
4.	23	9	63	48
5.	25	10	73	49
6.	8	3	79	50
7.	4	2	82	51
8.	7	3	84	52
9.	9	4	87	53
10.	5	2	90	54
11.	2	1	92	55
12.	4	2	93	56
14.	4	2	95	58
15.	1	0	96	59
16.	2	1	96	60
17.	2	1	97	61
19.	1	0	98	63
30.	1	0	98	73
33.	1	0	99	76
64.	1	0	99	99
99.	2	1	99	99

NUMBER CF N/C CONTROLS: P-T-P/STRAIGHT LINE

VARIABLE 26 MEAN = 4.6667
NUMBER OF RESFCNSES = 117. RESPONSE PERCENTAGE= 28.06

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	31	26	13	44
2.	23	20	36	45
3.	14	12	52	47
4.	10	9	62	48
5.	10	9	71	50
6.	6	5	78	52
7.	4	3	82	53
8.	2	2	85	55
9.	4	3	87	57
10.	4	3	91	58
11.	2	2	93	60
12.	1	1	94	61
15.	2	2	96	66
17.	2	2	97	70
33.	1	1	99	96
50.	1	1	99	99

NUMBER OF N/C CONTROLS: CONTOUR

VARIABLE 27 MEAN = 10.0201
NUMBER OF RESPONSES = 298. RESPONSE PERCENTAGE= 71.46

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	36	12	6	44
2.	61	20	22	45
3.	29	10	37	45
4.	28	9	47	46
5.	18	6	55	47
6.	15	5	60	47
7.	8	3	64	48
8.	14	5	68	48
9.	15	5	73	49
10.	10	3	77	49
11.	4	1	79	50
12.	7	2	81	51
13.	4	1	83	51
14.	3	1	84	52
15.	6	2	86	52
16.	3	1	87	53
17.	1	0	88	53
18.	4	1	89	54
19.	2	1	90	55
20.	1	0	90	55
21.	1	0	90	56
24.	1	0	91	57
25.	2	1	91	58
26.	2	1	92	59
27.	4	1	93	59
29.	1	0	94	60
30.	1	0	94	61
33.	1	0	94	63
35.	1	0	95	64
36.	1	0	95	64
44.	1	0	95	69
50.	2	1	96	72
60.	1	0	96	78
66.	1	0	97	82
75.	1	0	97	87
83.	1	0	97	91
99.	7	2	99	99

NUMBER OF N/C CONTROLS: MINICOMPUTER

VARIABLE 28 MEAN = 4.6371
NUMBER OF RESPONSES = 124. RESPONSE PERCENTAGE= 29.74

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	49	40	20	46
2.	33	27	53	47
3.	9	7	70	48
4.	9	7	77	49
5.	3	2	82	50
6.	2	2	84	51
7.	3	2	86	52
8.	2	2	88	53
9.	5	4	91	54
10.	2	2	94	55
12.	1	1	95	57
13.	1	1	96	58
25.	1	1	96	69
32.	1	1	97	76
50.	2	2	98	94
88.	1	1	99	99

NUMBER OF OTHER TYPES OF N/C CONTROLS

VARIABLE 29 MEAN = 9.1111
NUMBER OF RESPONSES = 9. RESPONSE PERCENTAGE= 2.16

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	22	11	42
2.	2	22	33	43
3.	1	11	50	44
10.	2	22	67	50
19.	1	11	83	59
34.	1	11	94	73

NUMBER OF: 1=CNC;2=DNC;3=MICROPROCESSOR;4=OTHER

VARIABLE 30 MEAN = 2.5556
NUMBER OF RESPONSES = 9. RESPONSE PERCENTAGE= 2.16

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	22	11	36
2.	3	33	39	45
3.	1	11	61	53
4.	3	33	83	62

NUMBER OF AXIS
****

NUMBER OFAXIS: 2-AXIS

VARIABLE 31 MEAN = 7.5229
NUMBER OF RESPONSES = 306. RESPONSE PERCENTAGE= 73.38

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	43	14	7	44
2.	51	17	22	45
3.	44	14	38	46
4.	43	14	52	47
5.	17	6	62	48
6.	10	3	66	48
7.	16	5	71	49

8.	10	3	75	50
9.	19	6	80	51
10.	5	2	83	51
11.	3	1	85	52
12.	1	0	85	53
13.	4	1	86	54
14.	2	1	87	55
15.	7	2	89	55
16.	3	1	90	56
17.	3	1	91	57
18.	3	1	92	58
19.	3	1	93	59
20.	3	1	94	59
22.	1	0	95	61
26.	2	1	95	64
27.	1	0	96	65
29.	1	0	96	66
30.	2	1	97	67
31.	1	0	97	68
36.	1	0	98	72
38.	1	0	98	74
50.	1	0	98	83
73.	1	0	99	99
80.	1	0	99	99
99.	3	1	99	99

NUMBER OF AXIS: 3-AXIS

VARIABLE 32 MEAN = 6.6029
NUMBER OF RESPONSES = 277. RESPONSE PERCENTAGE= 66.43

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	55	20	10	44
2.	43	16	28	45
3.	38	14	42	46
4.	23	8	53	47
5.	25	9	62	48
6.	10	4	68	49
7.	7	3	71	50
8.	7	3	74	51
9.	22	8	79	52
10.	9	3	85	53
11.	4	1	87	54
12.	1	0	88	55
14.	2	1	88	57
15.	2	1	89	58
16.	4	1	90	60
17.	4	1	92	61
18.	2	1	93	62
19.	1	0	93	63
20.	2	1	94	64
21.	2	1	95	65
22.	2	1	95	66
23.	2	1	96	67
25.	1	0	97	69
27.	1	0	97	71

30.	1	0	97	74
37.	2	1	98	82
38.	1	0	98	83
40.	1	0	99	85
48.	1	0	99	94
50.	1	0	99	96
99.	1	0	99	99

NUMBER OF AXIS: 4-AXIS

VARIABLE 33 MEAN = 4.0465
NUMBER OF RESPONSES = 129. RESPONSE PERCENTAGE= 30.94

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	53	41	21	45
2.	25	19	51	46
3.	10	8	64	48
4.	8	6	71	49
5.	3	2	76	51
6.	10	8	81	53
7.	2	2	85	54
8.	4	3	88	56
9.	7	5	92	57
10.	2	2	95	59
16.	1	1	97	68
22.	1	1	97	78
25.	1	1	98	82
40.	1	1	99	99
50.	1	1	99	99

NUMBER OF AXIS: 5-AXIS

VARIABLE 34 MEAN = 5.5455
NUMBER OF RESPONSES = 55. RESPONSE PERCENTAGE= 13.19

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	23	42	21	45
2.	13	24	54	46
3.	3	5	68	47
4.	3	5	74	48
5.	1	2	77	49
6.	2	4	80	50
7.	1	2	83	51
8.	2	4	85	52
13.	1	2	88	57
14.	1	2	90	58
17.	1	2	92	60
20.	1	2	94	63
33.	1	2	95	76
37.	1	2	97	80
61.	1	2	99	99

NUMBER OF AXIS: NUMBER OF OTHER TYPE

VARIABLE 35 MEAN = 1.6250
NUMBER OF RESPONSES = 8. RESPONSE PERCENTAGE= 1.92

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	5	63	31	43
2.	2	25	75	53
4.	1	13	94	73

NUMBER OF AXIS:(1=2+2AXIS;2=OTHERS)

VARIABLE 36 MEAN = 1.8750
NUMBER OF RESPONSES = 8. RESPONSE PERCENTAGE= 1.92

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	38	19	40
2.	4	50	63	51
4.	1	13	94	72

APPENDIX L

Survey Result Tables for

Industrial Group (Part I-B of Survey Instrument)

Percentage Time of each Part Programming Technique used

Percentage of each Source for Training of N/C-Personnel

Estimated Number of new Personnel for the next five years

Use of Timeshare or own Computer

Years of N/C Machine Tool Use

Number of N/C Machines to be purchased

Note: THE FOLLOWING TABLES SUMMARIZE ALL ORIGINAL RESPONSES BY INDUSTRIAL AND EDUCATIONAL SURVEY PARTICIPANTS

All responses are Raw Scores and Means are not adjusted for overall number of responses per group of questions (as underlined with asterisks).

Therefore, since multiple answers per group of questions occur frequently, Means are not cumulative and percentages of all questions within groups do not total 100 percent.

Tables in Chapter IV, however, are adjusted for individual question mean responses by taking into account the overall number of responses per group of questions. This accounts for possible differences between Raw Score Means and adjusted means as described in the data analysis.

PERCENTAGE TIME OF EACH
PROGRAMMING TECHNIQUE USED
****

MANUAL POINT-TO-POINT

VARIABLE 1 MEAN = 27.7382
NUMBER OF RESPONSES = 191. RESPONSE PERCENTAGE= 45.80

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
0.	10	5	3	40
3.	10	5	8	41
6.	30	16	18	42
11.	36	19	36	44
14.	11	6	48	45
17.	1	1	51	46
20.	17	9	56	47
25.	7	4	62	49
30.	8	4	66	51
33.	4	2	69	52
39.	11	6	73	54
50.	11	6	79	58
61.	12	6	85	62
66.	2	1	88	64
69.	3	2	90	65
74.	2	1	91	67
80.	4	2	93	69
91.	3	2	95	73
96.	2	1	96	75
99.	7	4	98	76

NOTE: Tables list original survey responses for each of 35 questions to Part I-B of the questionnaire for a total of 417 companies responding in the following manner:

(1) Variable Number corresponds to the same number on the Input Data Code Sheets.

(2) Mean represents the average (number or percentage) of all raw scores and their respective frequencies to the particular question.

(3) Number of Responses refers to the completed answers to each question only.

(4) Response Percentage is based on the total number of questionnaires received and the number of responses per question.

(5) Raw Score and Frequency list all individual answers with the respective number each value occurs (frequency).

(6) Percentage, Percentile, Standard list the specific distribution of each response per question.

P-TO-P/STRAIGHT LINE

VARIABLE 2 MEAN = 28.2941
NUMBER OF RESPONSES = 102. RESPONSE PERCENTAGE= 24.46

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	8	8	4	40
4.	17	17	16	41
7.	1	1	25	42
10.	16	16	33	43
15.	6	6	44	45
18.	2	2	48	46
20.	6	6	52	47
26.	4	4	57	49
31.	8	8	63	51
34.	3	3	68	52
36.	1	1	70	53
39.	7	7	74	54
50.	8	8	81	58
60.	2	2	86	62
71.	4	4	89	66
79.	2	2	92	69
84.	1	1	94	71
90.	1	1	95	73
95.	3	3	97	75
100.	2	2	99	77

MANUAL CONTOUR

VARIABLE 3 MEAN = 30.0890
NUMBER OF RESPONSES = 146. RESPONSE PERCENTAGE= 35.01

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
0.	3	2	1	39
3.	6	4	4	40
6.	22	15	14	41
9.	1	1	22	42
11.	28	19	32	43
14.	2	1	42	44
17.	1	1	43	45
19.	8	5	46	46
25.	8	5	51	48
30.	16	11	60	50
33.	4	3	66	51
35.	1	1	68	52
41.	7	5	71	54
49.	16	11	79	57
60.	8	5	87	61
70.	2	1	90	65
81.	1	1	91	69
84.	1	1	92	70
89.	3	2	93	72
95.	2	1	95	74
100.	6	4	98	76

COMPUTER IN-HOUSE LANGUAGE

VARIABLE 4 MEAN = 60.6216
NUMBER OF RESPONSES = 74. RESPONSE PERCENTAGE= 17.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
3.	1	1	1	32
6.	4	5	4	33
9.	6	8	11	34
19.	1	1	16	37
25.	2	3	18	39
29.	3	4	21	40
32.	1	1	24	41
41.	4	5	27	44
51.	12	16	38	47
61.	6	8	50	50
64.	1	1	55	51
70.	2	3	57	53
73.	1	1	59	54
80.	3	4	61	56
86.	2	3	65	58
89.	6	8	70	59
93.	1	1	75	60
96.	6	8	80	61
99.	12	16	92	62

APT-PROGRAMMING

VARIABLE 5 MEAN = 66.0571
NUMBER OF RESPONSES = 140. RESPONSE PERCENTAGE= 33.57

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
3.	1	1	1	31
6.	4	3	2	32
10.	12	9	8	33
13.	1	1	12	34
16.	1	1	13	35
20.	5	4	15	36
26.	3	2	18	38
30.	6	4	21	39
36.	1	1	24	41
40.	8	6	27	42
50.	10	7	34	45
56.	2	1	38	47
59.	1	1	39	48
66.	1	1	40	50
69.	3	2	41	51
76.	5	4	44	53
79.	11	8	50	54
86.	8	6	56	56
89.	16	11	65	57
96.	8	6	74	59
99.	33	24	88	60

PERCENTAGE OF OTHER LANGUAGES

VARIABLE 6 MEAN = 56.8896
NUMBER OF RESPONSES = 154. RESPONSE PERCENTAGE= 36.93

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	1	1	33
2.	3	2	2	33
3.	1	1	3	33
5.	6	4	5	34
8.	1	1	7	35
10.	12	8	12	35
12.	1	1	16	36
15.	4	3	18	37
20.	4	3	20	38
25.	6	4	23	40
30.	8	5	28	41
33.	2	1	31	42
40.	7	5	34	44
50.	18	12	42	47
55.	1	1	48	49
60.	9	6	52	50
65.	1	1	55	52
70.	7	5	57	53
75.	5	3	61	55
80.	9	6	66	56
85.	3	2	70	58
90.	14	9	75	59
95.	5	3	81	61
96.	1	1	83	61
98.	1	1	84	62
99.	24	16	92	62

TYPE OF OTHER LANGUAGE
(1= COMPACT II (MDSI);2= ADAPT;3= UNIAPT;4= SPLIT
5= ACTION;6=LEBLOND (TOOL PATH);7= GETURN
8= INTERACTIVE GRAPHICS.CAD;9= OTHERS)

VARIABLE 7 MEAN = 2.5229
NUMBER OF RESPONSES = 153. RESPONSE PERCENTAGE= 36.69

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	96	63	31	44
2.	14	9	67	47
3.	8	5	75	51
4.	6	4	79	55
5.	7	5	83	59
6.	4	3	87	63
7.	3	2	89	67
8.	1	1	91	71
9.	14	9	95	75

PERCENTAGE OF EACH
SOURCE FOR TRAINING OF N/C PERSONNEL
****

IN-HOUSE TRAINING

VARIABLE 8 MEAN = 72.3333
NUMBER OF RESPONSES = 333. RESPONSE PERCENTAGE= 79.86

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	1	0	1	24
5.	1	0	1	25
10.	11	3	2	27
16.	1	0	4	29
21.	11	3	6	31
24.	8	2	9	32
29.	12	4	12	34
35.	2	1	14	36
40.	10	3	16	38
51.	37	11	23	42
56.	1	0	28	44
59.	11	3	30	43
64.	3	1	32	47
70.	18	5	35	49
75.	15	5	40	51
80.	32	10	47	53
83.	1	0	52	54
86.	9	3	54	55
89.	1	0	55	56
91.	62	19	65	57
94.	18	5	77	58
99.	68	20	90	60

EQUIPMENT MANUFACTURERS

VARIABLE 9 MEAN = 26.1507
NUMBER OF RESPONSES = 219. RESPONSE PERCENTAGE= 52.52

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
0.	6	3	1	40
3.	10	5	5	41
8.	34	16	15	42
11.	58	26	36	44
16.	5	2	50	46
21.	18	8	56	48
26.	17	8	64	50
29.	15	7	71	51
34.	2	1	75	53
39.	3	1	76	55
44.	1	0	77	57
49.	19	9	82	59
60.	8	4	88	63
70.	1	0	90	67
75.	5	2	91	69
81.	6	3	94	71
91.	5	2	96	75
101.	6	3	99	79

CONTROL MANUFACTURERS

VARIABLE 10 MEAN = 14.6517
NUMBER OF RESPONSES = 89. RESPONSE PERCENTAGE= 21.34

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	3	2	40
2.	4	4	6	40
3.	1	1	8	41
5.	25	28	23	43
10.	23	26	50	46
15.	5	6	66	50
20.	12	13	75	53
25.	7	8	86	57
30.	1	1	90	61
45.	1	1	92	71
50.	6	7	96	75
70.	1	1	99	90

SERVICE BUREAUS

VARIABLE 11 MEAN = 24.1714
NUMBER OF RESPONSES = 35. RESPONSE PERCENTAGE= 8.39

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	6	3	41
4.	4	11	11	42
9.	14	40	37	44
14.	2	6	60	46
19.	1	3	64	48
24.	1	3	67	50
29.	3	9	73	52
39.	1	3	79	56
49.	3	9	84	60
55.	1	3	90	62
75.	1	3	93	70
98.	1	3	96	79
100.	1	3	99	80

HIGHER EDUCATION INSTITUTIONS

VARIABLE 12 MEAN = 19.9412
NUMBER OF RESPONSES = 51. RESPONSE PERCENTAGE= 12.23

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	4	2	41
6.	10	20	14	43
10.	19	37	42	45
16.	2	4	63	48
18.	1	2	66	49
20.	2	4	69	50
24.	1	2	72	52
30.	5	10	77	55
40.	3	6	85	60
51.	4	8	92	65
90.	1	2	97	84
100.	1	2	99	89

VOCATICNAL/TECHN. HIGH SCHOCL

VARIABLE 13 MEAN = 19.7647
NUMBER OF RESPCNSES = 34. RESPONSE PERCENTAGE= 8.15

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	1	3	1	40
5.	6	18	12	41
10.	15	44	43	44
20.	4	12	71	50
40.	1	3	78	61
50.	6	18	88	66
70.	1	3	99	77

JUNIOR OR CCMMUNITY COLLEGE

VARIABLE 14 MEAN = 21.5286
NUMBER OF RESPCNSES = 70. RESPONSE PERCENTAGE= 16.79

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
0.	3	4	2	40
2.	3	4	6	41
4.	12	17	17	42
11.	18	26	39	45
15.	1	1	52	47
19.	13	19	62	49
26.	3	4	74	52
30.	3	4	78	54
32.	1	1	81	55
34.	1	1	82	56
49.	7	10	88	63
71.	2	3	94	73
79.	2	3	97	77
101.	1	1	99	87

PERCENTAGE OF CTHER TRAINING

VARIABLE 15 MEAN = 32.9600
NUMBER OF RESPCNSES = 25. RESPONSE PERCENTAGE= 6.00

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	1	4	2	39
5.	3	12	10	40
10.	4	16	24	42
15.	3	12	38	44
20.	2	8	48	45
25.	2	8	56	47
30.	2	8	64	49
33.	1	4	70	50
50.	2	8	76	55
70.	1	4	82	62
75.	1	4	86	63
96.	1	4	90	70
99.	2	8	96	71

TYPES OF OTHER TRAINING
(1=INDUSTRY;2=SOFTWARE SERVICES,NCS, SME, MDSI;3=OTHER)

VARIABLE 16 MEAN = 2.8261
NUMBER OF RESPONSES = 23. RESPONSE PERCENTAGE= 5.52

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	13	57	28	44
3.	8	35	74	51
6.	1	4	93	70
9.	1	4	98	89

ESTIMATED NUMBER OF NEW PERSONNEL FOR THE NEXT FIVE YEARS

MANNUAL PROGRAMMERS

VARIABLE 17 MEAN = 1.5811
NUMBER OF RESPONSES = 74. RESPONSE PERCENTAGE= 17.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	50	68	34	45
2.	17	23	79	53
3.	3	4	93	60
4.	1	1	95	68
5.	2	3	97	76
10.	1	1	99	99

APT PROGRAMMERS

VARIABLE 18 MEAN = 4.6491
NUMBER OF RESPONSES = 114. RESPONSE PERCENTAGE= 27.34

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	35	31	15	45
2.	35	31	46	46
3.	16	14	68	48
4.	4	4	77	49
5.	8	7	82	50
6.	1	1	86	51
8.	2	2	88	53
9.	1	1	89	54
10.	7	6	93	56
40.	3	3	97	90
50.	2	2	99	99

NUMBER OF OTHER PROGRAMMERS

VARIABLE 19 MEAN = 2.6100
NUMBER OF RESPONSES = 100. RESPONSE PERCENTAGE= 23.98

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	40	40	20	43
2.	33	33	57	47
3.	8	8	77	51
4.	5	5	84	55
5.	3	3	88	60
7.	1	1	90	68
8.	1	1	91	72
9.	9	9	96	77

TYPE OF OTHER PROGRAMMERS:(1= COMPACT II (MDSI)
2=ADAPT;3= UNIAPT;4= APLIT;5= DNC OR CNC
6= SOFTWARE/SYSTEMS;7= COMPUTER GRAPHICS
8= POST PROCESSOR;9= OTHERS)

VARIABLE 20 MEAN = 4.2717
NUMBER OF RESPONSES = 92. RESPONSE PERCENTAGE= 22.06

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	41	45	22	40
2.	2	2	46	43
3.	6	7	50	46
4.	3	3	55	49
5.	5	5	59	52
6.	4	4	64	55
7.	4	4	68	57
8.	2	2	72	60
9.	25	27	86	63

N/C MACHINE OPERATORS

VARIABLE 21 MEAN = 10.5882
NUMBER OF RESPONSES = 238. RESPONSE PERCENTAGE= 57.07

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	3	1	43
2.	28	12	9	43
3.	28	12	21	44
4.	28	12	32	45
5.	24	10	43	45
6.	20	8	53	46
7.	4	2	58	47
8.	12	5	61	48
9.	4	2	64	48
10.	26	11	71	49
11.	1	0	76	50
12.	6	3	78	51
15.	9	4	81	53
16.	1	0	83	53
20.	13	5	86	56
21.	1	0	89	57
24.	1	0	89	59
25.	3	1	90	60
30.	9	4	93	64
35.	1	0	95	67
36.	2	1	95	68
40.	2	1	96	71
42.	1	0	97	72
45.	2	1	97	74
50.	1	0	98	78
60.	1	0	99	85
90.	1	0	99	99
99.	2	1	99	99

N/C MAINTENANCE PERSONNEL

VARIABLE 22 MEAN = 3.0361
NUMBER OF RESPONSES = 166. RESPONSE PERCENTAGE= 39.81

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	78	47	23	45
2.	45	27	61	47
3.	13	8	78	49
4.	4	2	83	52
5.	9	5	87	54
8.	2	1	90	61
10.	7	4	93	66
12.	1	1	95	70
15.	4	2	97	77
20.	1	1	98	89
28.	1	1	99	99
30.	1	1	99	99

N/C SUPERVISORS

VARIABLE 23 MEAN = 1.5851
NUMBER OF RESPONSES = 94. RESPONSE PERCENTAGE= 22.54

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	61	65	32	43
2.	19	20	75	54
3.	9	10	90	64
4.	2	2	96	74
5.	3	3	98	85

NUMBER OF OTHERS

VARIABLE 24 MEAN = 2.0000
NUMBER OF RESPONSES = 6. RESPONSE PERCENTAGE= 1.44

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	50	25	41
2.	1	17	58	50
3.	1	17	75	58
4.	1	17	92	67

TYPE OF OTHERS
(1= SERVICE/FIELD PERSONNEL;2= OTHERS)

VARIABLE 25 MEAN = 1.3333
NUMBER OF RESPONSES = 6. RESPONSE PERCENTAGE= 1.44

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	4	67	33	42
2.	2	33	83	64

USE OF TIME SHARE OR OWN COMPUTER
(1=TIME SHARE;2=OWN COMPUTER;3=BOTH)

VARIABLE 26 MEAN = 1.5974
NUMBER OF RESPONSES = 308. RESPONSE PERCENTAGE= 73.86

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	159	52	26	41
2.	114	37	70	55
3.	35	11	94	70

YEARS OF N/C MACHINE TOOL USE

VARIABLE 27 MEAN = 9.7029
NUMBER OF RESPONSES = 340. RESPONSE PERCENTAGE= 81.53

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	2	1	32
2.	22	6	5	34
3.	17	5	11	36
4.	9	3	15	38
5.	20	6	19	40
6.	14	4	24	42
7.	21	6	29	44
8.	31	9	37	46
9.	13	4	43	48
10.	63	19	55	50
11.	15	4	66	52
12.	20	6	71	54
13.	8	2	75	56
14.	13	4	78	58
15.	24	7	84	60
16.	9	3	89	62
17.	6	2	91	64
18.	13	4	94	66
19.	1	0	96	68
20.	11	3	97	71
21.	1	0	99	73
22.	2	1	99	75

NUMBER OF N/C MACHINES TO BE PURCHASED

NUMBER OF N/C DRILLS

VARIABLE 28 MEAN = 2.0857
NUMBER OF RESPONSES = 35. RESPONSE PERCENTAGE= 8.39

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	20	57	29	44
2.	8	23	69	49
3.	1	3	81	55
4.	1	3	84	60
5.	3	9	90	65
6.	1	3	96	71
9.	1	3	99	87

NUMBER OF N/C MILLS

VARIABLE 29 MEAN = 2.3469
NUMBER OF RESPONSES = 49. RESPONSE PERCENTAGE= 11.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	28	57	29	44
2.	8	16	65	48
3.	5	10	79	52
5.	2	4	86	61
6.	2	4	90	66
7.	1	2	93	70
9.	3	6	97	79

NUMBER OF N/C LATHES

VARIABLE 30 MEAN = 2.6694
NUMBER OF RESPONSES = 124. RESPONSE PERCENTAGE= 29.74

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	41	33	17	42
2.	48	39	52	46
3.	10	8	76	51
4.	4	3	81	56
5.	6	5	85	60
6.	4	3	90	65
7.	1	1	92	69
8.	3	2	93	74
9.	7	6	97	78

NUMBER OF N/C MACHINING CENTERS

VARIABLE 31 MEAN = 2.7386
NUMBER OF RESPONSES = 88. RESPONSE PERCENTAGE= 21.10

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	37	42	21	42
2.	24	27	56	46
3.	4	5	72	51
4.	4	5	76	55
5.	6	7	82	59
6.	5	6	88	63
7.	2	2	92	68
9.	6	7	97	76

NUMBER OF N/C GRINDERS

VARIABLE 32 MEAN = 1.8000
NUMBER OF RESPONSES = 5. RESPONSE PERCENTAGE= 1.20

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	60	30	41
3.	2	40	80	62

NUMBER OF PUNCHES

VARIABLE 33 MEAN = 1.0000
NUMBER OF RESPONSES = 4. RESPONSE PERCENTAGE= 0.96

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	4	100	50	50

NUMBER OF N/C FLAME CUTTERS

VARIABLE 34 MEAN = 0.0000
NUMBER OF RESPONSES = 1. RESPONSE PERCENTAGE= 0.24

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	100	50	50

NUMBER OF OTHER N/C

VARIABLE 35 MEAN = 3.2353
NUMBER OF RESPONSES = 17. RESPONSE PERCENTAGE= 4.08

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	35	18	41
2.	2	12	41	45
3.	3	18	56	49
4.	2	12	71	53
5.	2	12	82	57
9.	2	12	94	72

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APPENDIX M

Survey Result Tables for

Educational Group (Part I-A of Survey Instrument)

Number of Faculty per Department

Number of Students per Department

Main Teaching Area of Respondent

Competency in N/C acquired

Number of N/C Machine Tools

Number of Non-N/C Machine Tools

Note: THE FOLLOWING TABLES SUMMARIZE ALL ORIGINAL RESPONSES BY INDUSTRIAL AND EDUCATIONAL SURVEY PARTICIPANTS

All responses are Raw Scores and Means are not adjusted for overall number of responses per group of questions (as underlined with asterisks).

Therefore, since multiple answers per group of questions occur frequently, Means are not cumulative and percentages of all questions within groups do not total 100 percent.

Tables in Chapter IV, however, are adjusted for individual question mean responses by taking into account the overall number of responses per group of questions. This accounts for possible differences between Raw Score Means and adjusted means as described in the data analysis.

NUMBER OF FACULTY PER DEPARTMENT

FULL TIME FACULTY PER DEPT.

VARIABLE 1 MEAN = 9.9706
NUMBER OF RESPONSES = 102. RESPONSE PERCENTAGE= 93.58

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	7	3	39
2.	4	4	9	40
3.	14	14	18	41
4.	7	7	28	42
5.	14	14	38	44
6.	6	6	48	45
7.	2	2	52	46
8.	2	2	54	47
9.	4	4	57	48
10.	1	1	59	50
11.	1	1	60	51
12.	5	5	63	52
13.	6	6	69	53
14.	4	4	74	54
15.	6	6	78	55
16.	1	1	82	57
17.	1	1	83	58
18.	4	4	88	59
19.	1	1	88	60
20.	1	1	89	61
21.	2	2	90	63
24.	2	2	92	66
26.	2	2	94	68
27.	1	1	96	70
28.	1	1	97	71
29.	1	1	98	72
40.	1	1	99	85
45.	1	1	99	91

NOTE: Tables list original survey responses for each of 26 questions to Part I-A of the questionnaire for a total of 84 institutions responding in the following manner:

(1) Variable Number corresponds to the same number on the Input Data Code Sheets.
(2) Mean represents the average (number or percentage) of all raw scores and their respective frequencies to the particular question.
(3) Number of Responses refers to the completed answers to each question only.
(4) Response Percentage is based on the total number of questionnaires received and the number of responses per question.
(5) Raw Score and Frequency list all individual answers with the respective number each value occurs (frequency).
(6) Percentage, Percentile, Standard list the specific distribution of each response per question.

PART TIME FACULTY PER DEPT.

VARIABLE 2 MEAN = 4.6557
NUMBER OF RESPONSES = 61. RESPONSE PERCENTAGE= 55.96

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	10	16	8	40
2.	15	25	29	43
3.	8	13	48	45
4.	5	8	58	48
5.	3	5	65	50
6.	6	10	72	53
7.	1	2	78	55
8.	5	8	83	58
10.	2	3	89	63
12.	2	3	93	68
13.	1	2	96	71
15.	1	2	98	76
20.	1	2	99	89

FACULTY TEACHING N/C PER DEPT.

VARIABLE 3 MEAN = 1.5882
NUMBER OF RESPONSES = 68. RESPONSE PERCENTAGE= 62.39

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	42	62	31	44
2.	19	28	76	53
3.	4	6	93	63
4.	2	3	97	72
8.	1	1	99	99

NUMBER OF STUDENTS PER DEPARTMENT
****

NUMBER OF MAJORS

VARIABLE 4 MEAN = 206.8291
NUMBER OF RESPONSES = 87. RESPONSE PERCENTAGE= 79.82

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
8.	5	6	3	40
28.	5	6	9	41
48.	10	11	17	42
68.	7	8	27	43
88.	4	5	33	44
108.	9	10	41	45
127.	3	3	48	46
147.	8	9	54	47
167.	3	3	60	48
187.	1	1	63	49
207.	3	3	65	50
227.	2	2	68	51
247.	2	2	70	52

266.	1	1	72	53
306.	3	3	74	55
346.	3	3	78	57
366.	1	1	80	58
405.	7	8	84	60
445.	2	2	90	62
504.	1	1	91	65
584.	1	1	93	69
604.	2	2	94	70
703.	1	1	96	75
802.	2	2	98	80
901.	1	1	99	85

NUMBER OF NON-MAJORS

VARIABLE 5 MEAN = 121.0000
NUMBER OF RESPONSES = 51. RESPONSE PERCENTAGE= 46.79

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
10.	7	14	7	42
24.	9	18	23	43
38.	3	6	34	44
52.	7	14	44	45
66.	1	2	52	46
79.	2	4	58	47
93.	6	12	63	48
107.	1	2	70	49
190.	2	4	73	55
204.	6	12	80	56
287.	1	2	87	62
356.	1	2	89	67
398.	3	6	93	70
495.	1	2	97	77
605.	1	2	99	88

NUMBER TAKING N/C COURSES PER YEAR

VARIABLE 6 MEAN = 40.3500
NUMBER OF RESPONSES = 60. RESPONSE PERCENTAGE= 55.05

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
11.	4	7	3	41
14.	6	10	12	42
18.	1	2	17	43
21.	8	13	25	44
24.	8	13	38	45
31.	6	10	50	47
34.	1	2	56	48
40.	8	13	63	50
44.	2	3	72	51
50.	5	8	77	53
53.	1	2	82	54
60.	2	3	85	56
63.	1	2	87	57
76.	1	2	89	61
79.	1	2	91	62
99.	2	3	93	68
119.	2	3	97	74
200.	1	2	99	99

MAIN TEACHING AREA OF RESPONDENT
****

YEARS IN INDUSTRIAL ARTS

VARIABLE 7 MEAN = 10.0816
NUMBER OF RESPONSES = 49. RESPONSE PERCENTAGE= 44.95

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	4	8	4	38
2.	2	4	10	39
3.	3	6	15	41
4.	2	4	20	42
5.	6	12	29	43
6.	4	8	39	44
7.	2	4	45	46
8.	2	4	49	47
9.	4	8	55	48
10.	6	12	69	49
13.	1	2	72	53
14.	3	6	77	54
16.	1	2	81	57
19.	2	4	84	61
20.	1	2	87	62
21.	1	2	89	63
22.	1	2	91	65
25.	1	2	93	68
26.	1	2	95	70
30.	1	2	97	75
36.	1	2	99	82

YEARS IN VOCATIONAL EDUCATION

VARIABLE 8 MEAN = 8.0000
NUMBER OF RESPONSES = 27. RESPONSE PERCENTAGE= 24.77

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	7	4	39
2.	4	15	15	41
3.	3	11	28	42
4.	4	15	41	44
5.	2	7	52	45
8.	2	7	59	50
9.	1	4	65	51
10.	3	11	72	52
12.	1	4	80	55
16.	1	4	83	61
17.	1	4	87	62
21.	1	4	91	68
24.	1	4	94	72
26.	1	4	98	75

YEARS IN TECHNICAL EDUCATION

VARIABLE 9 MEAN = 6.5455
NUMBER OF RESPONSES = 22. RESPONSE PERCENTAGE= 20.18

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	5	2	37
2.	3	14	11	39
3.	1	5	20	42
4.	4	18	32	44
5.	3	14	48	46
6.	2	9	59	48
7.	3	14	70	51
12.	2	9	82	62
13.	1	5	89	64
14.	1	5	93	66
19.	1	5	98	77

YEARS IN INDUSTRIAL TECHNOLOGY

VARIABLE 10 MEAN = 6.4839
NUMBER OF RESPONSES = 31. RESPONSE PERCENTAGE= 28.44

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	10	5	37
2.	1	3	11	39
3.	6	19	23	41
4.	3	10	37	44
5.	3	10	47	46
6.	4	13	58	48
8.	1	3	66	53
10.	6	19	77	58
14.	2	6	90	67
15.	1	3	95	70
16.	1	3	98	72

YEARS IN ENGINEERING TECHNOLOGY

VARIABLE 11 MEAN = 9.6250
NUMBER OF RESPONSES = 32. RESPONSE PERCENTAGE= 29.36

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	9	9	39
2.	2	6	13	40
3.	1	3	17	41
4.	4	13	25	42
5.	3	9	34	44
6.	3	9	43	45
7.	2	6	53	46
10.	2	6	59	50
11.	2	6	66	51
12.	2	6	72	53
13.	1	3	77	54
16.	1	3	80	58
17.	1	3	83	59
19.	1	3	86	61
20.	1	3	89	63
24.	1	3	92	68
30.	2	6	97	75

YEARS TOTAL

VARIABLE 12 MEAN = 13.8687
NUMBER OF RESPONSES = 99. RESPONSE PERCENTAGE= 90.83

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	1	1	35
2.	3	3	3	36
3.	3	3	6	38
4.	6	6	10	39
5.	4	4	14	40
6.	8	8	20	41
7.	4	4	25	42
8.	2	2	29	43
9.	5	5	33	44
10.	10	10	40	45
11.	4	4	47	46
12.	5	5	52	47
13.	3	3	56	49
14.	6	6	60	50
15.	2	2	64	51
16.	6	6	67	52
17.	1	1	70	53
18.	3	3	72	54
19.	3	3	75	55
20.	3	3	78	56
21.	2	2	81	57
22.	2	2	83	58
24.	2	2	85	61
25.	1	1	86	62
26.	4	4	89	63
28.	1	1	91	65
30.	4	4	94	67
33.	1	1	96	70
36.	1	1	97	74
44.	1	1	98	83
45.	1	1	99	84

COMPETENCY IN N/C ACQUIRED

YEARS OF FORMAL EDUCATION IN N/C

VARIABLE 13 MEAN = 1.4595
NUMBER OF RESPONSES = 37. RESPONSE PERCENTAGE= 33.94

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	29	78	39	45
2.	4	11	84	55
3.	1	3	91	64
4.	1	3	93	74
5.	2	5	97	83

YEARS OF CORRESPONDENCE COURSES IN N/C

VARIABLE 14 MEAN = 1.0000
NUMBER OF RESPONSES = 2. RESPONSE PERCENTAGE= 1.83

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	100	50	50

YEARS OF N/C TEACHING EXPERIENCE

VARIABLE 15 MEAN = 5.4681
NUMBER OF RESPONSES = 47. RESPONSE PERCENTAGE= 43.12

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	13	6	36
2.	2	4	15	39
3.	8	17	26	42
4.	5	11	39	45
5.	7	15	52	48
6.	2	4	62	51
7.	3	6	67	54
8.	4	9	74	57
9.	2	4	81	60
10.	6	13	89	64
11.	1	2	97	67
14.	1	2	99	76

YEARS OF N/C WORK EXPERIENCE

VARIABLE 16 MEAN = 3.8667
NUMBER OF RESPONSES = 30. RESPONSE PERCENTAGE= 27.52

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	23	12	40
2.	5	17	32	43
3.	5	17	48	46
4.	4	13	63	50
5.	2	7	73	53
6.	2	7	80	57
7.	1	3	85	60
8.	1	3	88	64
9.	1	3	92	67
10.	1	3	95	71
12.	1	3	98	78

YEARS N/C SELF-TAUGHT

VARIABLE 17 MEAN = 4.0000
NUMBER OF RESPONSES = 52. RESPONSE PERCENTAGE= 47.71

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	16	31	15	40
2.	7	13	37	43
3.	8	15	52	46
4.	1	2	61	50
5.	7	13	68	53
6.	1	2	76	56
7.	3	6	80	59
8.	2	4	85	62
9.	2	4	88	65
10.	4	8	94	68
14.	1	2	99	80

TOTAL YEARS OF N/C BACKGROUND

VARIABLE 18 MEAN = 7.7375
NUMBER OF RESPONSES = 80. RESPONSE PERCENTAGE= 73.39

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	5	6	3	38
2.	9	11	12	40
3.	7	9	22	41
4.	3	4	28	43
5.	10	13	36	45
6.	5	6	46	46
7.	4	5	51	48
8.	9	11	59	50
10.	12	15	73	53
11.	2	2	81	55
12.	3	4	84	57
13.	1	1	87	59
14.	3	4	89	60
15.	1	1	92	62

18.	2	2	94	87
19.	1	1	96	89
23.	2	2	98	76
34.	1	1	99	95

NUMBER OF MACHINE TOOLS
****

N/C DRILLING MACHINES

VARIABLE 19 MEAN = 1.3333
NUMBER OF RESPONSES = 21. RESPONSE PERCENTAGE= 19.27

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	19	90	45	47
2.	1	5	93	55
7.	1	5	98	94

N/C MILLING MACHINES

VARIABLE 20 MEAN = 1.1525
NUMBER OF RESPONSES = 59. RESPONSE PERCENTAGE= 54.13

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	51	86	43	46
2.	7	12	92	70
3.	1	2	99	95

N/C LATHES

VARIABLE 21 MEAN = 1.0000
NUMBER OF RESPONSES = 6. RESPONSE PERCENTAGE= 5.50

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	100	50	50

N/C MACHINING CENTERS

VARIABLE 22 MEAN = 1.0000
NUMBER OF RESPONSES = 9. RESPONSE PERCENTAGE= 8.26

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	9	100	50	50

NUMBER OF NON N/C MACHINE TOOLS

NUMBER OF DRILLING MACHINES

VARIABLE 23 MEAN = 3.7612
NUMBER OF RESPONSES = 67. RESPONSE PERCENTAGE= 61.47

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	9	4	36
2.	12	18	18	41
3.	17	25	40	46
4.	16	24	64	51
5.	6	9	81	55
6.	3	4	87	60
7.	4	6	93	65
9.	1	1	96	75
10.	1	1	98	79
12.	1	1	99	89

NUMBER OF MILLING MACHINES

VARIABLE 24 MEAN = 4.9552
NUMBER OF RESPONSES = 67. RESPONSE PERCENTAGE= 61.47

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	4	2	38
2.	11	16	13	41
3.	13	19	31	44
4.	11	16	49	47
5.	12	18	66	50
6.	2	3	76	52
7.	4	6	81	55
8.	2	3	85	58
9.	2	3	88	61
10.	4	6	93	64
12.	1	1	96	70
17.	1	1	98	84
21.	1	1	99	95

NUMBER OF LATHES

VARIABLE 25 MEAN = 11.0735
NUMBER OF RESPONSES = 68. RESPONSE PERCENTAGE= 62.39

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	4	2	33
2.	1	1	5	34
4.	6	9	10	38
5.	1	1	15	39
6.	7	10	21	41
7.	2	3	28	43

8.	3	4	32	44
9.	4	6	37	46
10.	6	9	44	48
11.	3	4	51	49
12.	8	12	59	51
13.	6	9	69	53
14.	3	4	76	54
15.	2	3	79	56
16.	2	3	82	58
17.	2	3	85	59
18.	1	1	87	61
20.	4	6	91	64
21.	1	1	95	66
22.	1	1	96	68
25.	1	1	98	73
32.	1	1	99	85

NUMBER OF MACHINING CENTERS

VARIABLE 26 MEAN = 1.0000
NUMBER OF RESPONSES = 4. RESPONSE PERCENTAGE= 3.67

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	4	100	50	50

APPENDIX N

Survey Result Tables for

Educational Group (Part I-B of Survey Instrument)

Number of N/C Controls

Number of Axis

Percent Time of each Part Programming Technique used

Level of Courses offered in N/C

Duration and Size per N/C Course

Use of Timeshare Services or own Computer

Number of Years offered Instruction

Number of N/C Machine Tools to be purchased

Note: THE FOLLOWING TABLES SUMMARIZE ALL ORIGINAL RESPONSES BY INDUSTRIAL AND EDUCATIONAL SURVEY PARTICIPANTS

All responses are Raw Scores and Means are not adjusted for overall number of responses per group of questions (as underlined with asterisks).

Therefore, since multiple answers per group of questions occur frequently, Means are not cumulative and percentages of all questions within groups do not total 100 percent.

Tables in Chapter IV, however, are adjusted for individual question mean responses by taking into account the overall number of responses per group of questions. This accounts for possible differences between Raw Score Means and adjusted means as described in the data analysis.

NUMBER OF N/C CONTROLS
****

NUMBER OF POINT-TO-POINT

VARIABLE 1 MEAN = 1.0816
NUMBER OF RESPONSES = 49. RESPONSE PERCENTAGE= 44.95

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	47	96	48	48
2.	1	2	97	70
4.	1	2	99	99

NUMBER OF P-T-P/STRAIGHT LINE

VARIABLE 2 MEAN = 1.1200
NUMBER OF RESPONSES = 25. RESPONSE PERCENTAGE= 22.94

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	22	88	44	46
2.	3	12	94	77

NUMBER OF CONTOUR

VARIABLE 3 MEAN = 1.1739
NUMBER OF RESPONSES = 23. RESPONSE PERCENTAGE= 21.10

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	20	87	43	46
2.	2	9	91	67
3.	1	4	98	88

NOTE: Tables list original survey responses for each of 36 questions to Part I-B of the questionnaire for a total of 84 institutions responding in the following manner:

(1) Variable Number corresponds to the same number on the Input Data Code Sheets.
(2) Mean represents the average (number or percentage) of all raw scores and their respective frequencies to the particular question.
(3) Number of Responses refers to the completed answers to each question only.
(4) Response Percentage is based on the total number of questionnaires received and the number of responses per question.
(5) Raw Score and Frequency list all individual answers with the respective number each value occurs (frequency).
(6) Percentage, Percentile, Standard list the specific distribution of each response per question.

NUMBER OF MINICOMPUTERS

VARIABLE 4 MEAN = 1.1667
NUMBER OF RESPONSES = 6. RESPONSE PERCENTAGE= 5.50

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	5	83	42	45
2.	1	17	92	72

NUMBER OF AXIS
****

NUMBER OF AXIS: 2-AXIS

VARIABLE 5 MEAN = 1.1837
NUMBER OF RESPONSES = 49. RESPONSE PERCENTAGE= 44.95

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	42	86	43	46
2.	6	12	92	65
4.	1	2	99	99

NUMBER OF AXIS: 3-AXIS

VARIABLE 6 MEAN = 1.1714
NUMBER OF RESPONSES = 35. RESPONSE PERCENTAGE= 32.11

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	31	89	44	46
2.	2	6	91	66
3.	2	6	97	86

NO VALID DATA FOR VARIABLE 7

NUMBER OF AXIS: 5 OR MORE

VARIABLE 8 MEAN = 0.0000
NUMBER OF RESPONSES = 1. RESPONSE PERCENTAGE= 0.92

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	100	50	50

PERCENT TIME OF EACH PART PROGRAMMING TECHNIQUE USED
****

MANUAL POINT-TO-POINT

VARIABLE 9 MEAN = 42.5051
NUMBER OF RESPONSES = 44. RESPONSE PERCENTAGE= 40.37

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
4.	3	7	3	38
10.	6	14	14	40
14.	1	2	22	41
20.	7	16	31	43
23.	4	9	43	44
30.	3	7	51	46
33.	1	2	56	47
40.	1	2	58	49
46.	1	2	60	51
49.	4	9	66	52
59.	1	2	72	55
75.	2	5	75	60
79.	3	7	81	61
102.	7	16	92	68

MANUAL P-T-P / STRAIGHT LINE

VARIABLE 10 MEAN = 39.5814
NUMBER OF RESPONSES = 43. RESPONSE PERCENTAGE= 39.45

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
5.	2	5	2	39
9.	8	19	14	40
21.	9	21	34	44
24.	4	9	45	45
30.	3	7	57	47
40.	1	2	62	50
49.	6	14	70	53
71.	1	2	78	60
74.	1	2	80	61
80.	1	2	83	63
89.	2	5	86	66
99.	5	12	94	69

MANUAL CONTOUR

VARIABLE 11 MEAN = 22.6429
NUMBER OF RESPONSES = 28. RESPONSE PERCENTAGE= 25.69

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	4	2	38
5.	2	7	7	40
10.	11	39	30	43
20.	3	11	55	48
25.	2	7	64	51
30.	3	11	73	53
33.	1	4	80	55
40.	1	4	84	59
50.	3	11	91	64
90.	1	4	98	85

COMPUTER IN-HOUSE LANGUAGE

VARIABLE 12 MEAN = 26.7692
NUMBER OF RESPONSES = 13. RESPONSE PERCENTAGE= 11.93

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
3.	1	8	4	41
5.	1	8	12	42
11.	3	23	27	44
16.	2	15	46	46
19.	2	15	62	47
29.	1	8	73	51
51.	1	8	81	55
59.	1	8	88	62
95.	1	8	96	77

APT-PROGRAMMING

VARIABLE 13 MEAN = 36.2083
NUMBER OF RESPONSES = 24. RESPONSE PERCENTAGE= 22.02

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	4	2	38
3.	1	4	6	39
6.	1	4	10	40
9.	3	13	19	41
15.	1	4	27	43
21.	4	17	37	45
24.	2	8	50	46
30.	1	4	56	48
33.	1	4	60	49
39.	2	8	67	51
51.	1	4	73	55
60.	1	4	77	58
66.	1	4	81	60
81.	1	4	85	65
90.	1	4	90	68
96.	1	4	94	70
99.	1	4	98	71

TYPE OF OTHER LANGUAGE
(1= COMPACT II (MDSI);2= ADAPT;3= UNIAPT;4= SPLIT
5= ACTION;6=LEBLOND (TOOL PATH);7= GETURN
8= INTERACTIVE GRAPHICS.CAD;9= OTHERS)

VARIABLE 14 MEAN = 1.6667
NUMBER OF RESPONSES = 3. RESPONSE PERCENTAGE= 2.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	33	17	35
2.	2	67	67	57

PERCENTAGE OF OTHER LANGUAGES

VARIABLE 15 MEAN = 32.7500
NUMBER OF RESPONSES = 12. RESPONSE PERCENTAGE= 11.01

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
5.	1	8	4	35
10.	3	25	21	41
20.	2	17	42	45
30.	1	8	54	48
33.	1	8	62	50
35.	1	8	71	52
60.	1	8	79	60
70.	1	8	87	64
90.	1	8	96	72

TYPE OF OTHER LANGUAGE

VARIABLE 16 MEAN = 2.6250
NUMBER OF RESPONSES = 8. RESPONSE PERCENTAGE= 7.34

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	25	13	43
2.	5	63	56	47
9.	1	13	94	76

PERCENTAGE OF OTHER LANGUAGES

VARIABLE 17 MEAN = 22.5000
NUMBER OF RESPONSES = 8. RESPONSE PERCENTAGE= 7.34

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
5.	1	13	6	37
10.	2	25	25	41
20.	2	25	50	48
30.	1	13	69	55
35.	1	13	81	58
50.	1	13	94	69

LEVEL OF COURSES OFFERED IN N/C

NUMBER OF COURSES: FRESHMAN

VARIABLE 18 MEAN = 1.0000
NUMBER OF RESPONSES = 11. RESPONSE PERCENTAGE= 10.09

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	11	100	50	50

NUMBER OF COURSES: SOPHOMORE

VARIABLE 19 MEAN = 1.0000
NUMBER OF RESPONSES = 28. RESPONSE PERCENTAGE= 25.69

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	28	100	50	50

NUMBER OF COURSES: JUNIOR

VARIABLE 20 MEAN = 1.0000
NUMBER OF RESPONSES = 37. RESPONSE PERCENTAGE= 33.94

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	37	100	50	50

NUMBER OF COURSES: SENIOR

VARIABLE 21 MEAN = 1.0000
NUMBER OF RESPONSES = 33. RESPONSE PERCENTAGE= 30.28

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	33	100	50	50

DURATION AND SIZE PER N/C COURSE

NUMBER OF N/C COURSES

VARIABLE 22 MEAN = 1.6724
NUMBER OF RESPONSES = 58. RESPONSE PERCENTAGE= 53.21

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	33	57	28	43
2.	17	29	72	53
3.	5	9	91	62
4.	2	3	97	72
7.	1	2	99	99

NUMBER OF HOURS OF N/C INSTRUCTION

VARIABLE 23 MEAN = 30.5682
NUMBER OF RESPONSES = 44. RESPONSE PERCENTAGE= 40.37

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
2.	2	5	2	39
3.	2	5	7	39
4.	1	2	10	40
5.	2	5	14	40
6.	5	11	22	40
8.	1	2	28	41
10.	1	2	31	42
12.	2	5	34	43
15.	2	5	39	44
16.	1	2	42	44
17.	1	2	44	44
18.	1	2	47	45
20.	1	2	49	46
24.	1	2	51	47
30.	4	9	57	49
40.	3	7	65	53
45.	2	5	70	55
48.	3	7	76	56
50.	1	2	81	57
54.	1	2	83	58
60.	2	5	86	61
66.	2	5	91	63
96.	1	2	94	74
99.	2	5	98	75

LECTURE (HOURS PER WEEK)

VARIABLE 24 MEAN = 2.0426
NUMBER OF RESPONSES = 47. RESPONSE PERCENTAGE= 43.12

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	19	40	20	40
2.	13	28	54	49
3.	12	26	81	58
4.	1	2	95	67
5.	1	2	97	76
6.	1	2	99	85

LAB (HOURS PER WEEK)

VARIABLE 25 MEAN = 3.3111
NUMBER OF RESPONSES = 45. RESPONSE PERCENTAGE= 41.28

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	7	16	8	41
2.	11	24	28	44
3.	14	31	56	48
4.	8	18	80	52
5.	1	2	90	56
6.	1	2	92	60
8.	1	2	94	67
12.	1	2	97	83
15.	1	2	99	94

STUDENTS PER N/C COURSE

VARIABLE 26 MEAN = 18.5428
NUMBER OF RESPONSES = 70. RESPONSE PERCENTAGE= 64.22

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
5.	3	4	2	32
6.	1	1	5	33
8.	2	3	7	36
10.	1	1	9	38
12.	6	9	14	41
15.	15	21	29	45
16.	2	3	41	46
17.	1	1	44	47
18.	3	4	46	49
20.	20	29	63	51
22.	1	1	78	54
24.	4	6	81	57
25.	8	11	90	58
35.	1	1	96	71
48.	1	1	98	88
50.	1	1	99	91

STUDENTS PER LAB

VARIABLE 27 MEAN = 16.1475
NUMBER OF RESPONSES = 61. RESPONSE PERCENTAGE= 55.96

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	1	2	1	26
5.	5	8	6	32
6.	1	2	11	34
7.	1	2	12	35
10.	2	3	15	40
11.	1	2	17	42

12.	8	13	25	43
14.	1	2	32	46
15.	12	20	43	48
16.	2	3	54	49
17.	1	2	57	51
18.	1	2	58	52
20.	15	25	71	55
24.	3	5	86	62
25.	6	10	93	63
36.	1	2	95	80

STUDENTS PER ACADEMIC YEAR

VARIABLE 28 MEAN = 35.0370
NUMBER OF RESPONSES = 54. RESPONSE PERCENTAGE= 49.54

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
5.	1	2	1	36
8.	1	2	3	37
10.	3	6	6	38
12.	2	4	11	39
15.	4	7	17	40
18.	1	2	21	41
20.	4	7	26	42
22.	1	2	31	43
24.	4	7	35	44
25.	2	4	41	44
30.	3	6	45	46
32.	1	2	49	47
40.	9	17	58	50
45.	2	4	69	52
48.	1	2	71	53
50.	5	9	77	54
60.	2	4	83	58
75.	2	4	87	63
80.	1	2	90	65
99.	5	9	95	73

USE OF TIME-SHARE SERVICE OR OWN COMPUTER
****
(1=TIME SHARE;2=OWN COMPUTER;3=BOTH)

VARIABLE 29 MEAN = 1.5169
NUMBER OF RESPONSES = 37. RESPONSE PERCENTAGE= 33.94

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	6	16	8	31
2.	28	76	54	51
3.	3	8	96	72

NUMBER OF YEARS OFFERED INSTRUCTION
****

VARIABLE 30 MEAN = 5.2667
NUMBER OF RESPONSES = 75. RESPONSE PERCENTAGE= 68.81

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	5	7	3	34
2.	11	15	14	38
3.	7	9	26	41
4.	10	13	37	45
5.	10	13	51	49
6.	8	11	63	52
7.	3	4	70	56
8.	9	12	78	59
9.	6	8	88	63
10.	4	5	95	67
11.	2	3	99	70

NUMBER OF N/C MACHINE TOOLS TO BE PURCHASED
****

NUMBER OF N/C DRILLS

VARIABLE 31 MEAN = 1.0000
NUMBER OF RESPONSES = 2. RESPONSE PERCENTAGE= 1.83

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	2	100	50	50

NUMBER OF N/C MILLS

VARIABLE 32 MEAN = 1.1765
NUMBER OF RESPONSES = 17. RESPONSE PERCENTAGE= 15.60

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	15	88	44	46
2.	1	6	91	66
3.	1	6	97	85

NUMBER OF N/C LATHES

VARIABLE 33 MEAN = 1.0000
NUMBER OF RESPONSES = 20. RESPONSE PERCENTAGE= 18.35

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	20	100	50	50

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NUMBER OF N/C MACHINING CENTERS

VARIABLE 34 MEAN = 1.5000
NUMBER OF RESPONSES = 4. RESPONSE PERCENTAGE= 3.67

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	75	38	44
3.	1	25	88	67

NO VALID DATA FOR VARIABLE 35

NUMBER OF OTHER N/C

VARIABLE 36 MEAN = 1.0000
NUMBER OF RESPONSES = 3. RESPONSE PERCENTAGE= 2.75

RAW SCORE	FREQUENCY	PERCENTAGE	PERCENTILE	STANDARD
1.	3	100	50	50